

DEECKE (Theo)

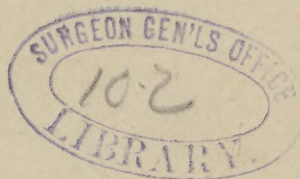
The Structure of the Vessels of the
Nervous Centers in Health, and
their Changes in Disease.

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Parts I and II.

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By THEODORE DEECKE, ✓

Special Pathologist, New York State Lunatic Asylum, Utica.

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From the *American Journal of Insanity* for July, 1877, and
January, 1879.



THE STRUCTURE OF THE VESSELS OF THE NERVOUS CENTERS IN HEALTH, AND THEIR CHANGES IN DISEASE.

BY THEODORE DEECKE,

Special Pathologist, New York State Lunatic Asylum, Utica.

Herbert C. Major in his observations on the histology of the morbid brain, remarks regarding the vessels of the brain.*

“Under this head my observations need be only very brief, for the state of the vessels in almost all forms of cerebral disease has always attracted much attention, and as they admit of easier study than most of the other elements, accurate descriptions are not wanting.”

This statement indeed can be only partly endorsed. It is true the special literature upon the subject in question abounds in most valuable observations, but the study of the minute, normal and abnormal structure of the vascular system of the nervous centers, seems to offer no less difficulties than that of its other elements in general, as the descriptions given, up to the present time, are imperfect and incorrect.

Since the year 1874, when the above quoted sentence was written, only a few points of any importance have been added to our knowledge. The existence of lymphatic ducts around the cerebral vessels, the perivascular canals of Virchow and Robin, has been more generally recognized. The most successful investigator of the subject B. Riedel,† has discovered anastomoses between

* West Riding Lunatic Asylum, medical reports, vol. 4, p. 235.

† B. Riedel, Die perivascularären Lymphräume im Central Nervensystem, etc., Archiv. Bd. XI page 272 ff.

these ducts, and regards the adventitia of the vessels of the nervous centers as the enveloping membrane of an independent lymphatic system, and as such, it is claimed to be lined by a separate layer of endothelium. Even the existence of the much discussed perivascular spaces of His has found its renowned advocate in R. Arndt,* who points out the genetic difference, and disconnection between the vascular system and the tissue of the brain itself. He denies any similarity of the peculiar prolongations, the cells of Roth, Golgi, Boll and others, adherent to the adventitious membrane of the arteries, with the so-called Deiter's cells of the neuroglia. The most recent article on normal and pathological anatomy of the cerebral vessels has been written by Obersteiner,† and as this publication exhibits the present state of knowledge on the subject, I will proceed to discuss in the following, especially the views laid down by its experienced author.

In regard to the method of investigation and the preparation of the objects employed, I give the following brief account in advance.

The insulation of the vessels from the brain tissue, and the transparency of the objects, permit of an examination, even with high, well penetrating and defining powers. Thus many interesting points of the normal and abnormal structure can be, and have been disclosed. But a true conception of the minutest structure, even of these comparatively large objects, can only be arrived at by the analysis of a number of series of the finest transverse sections, perfectly rectangular to the course of the vessel. These can be made with success, only by the aid

* R. Arndt, Ueber den Etat criblée Virchow Archiv. 1875, Bd. 63.

† Obersteiner, Beiträge zur pathologischen Anatomie der Gehirngefäße. Stricker, medicinische Jahrbücher, 1877, Heft. 2,

of a microtome which I always use. The insulated vessels hardened in bichromate of potash are embedded in a cast of paraffine and oil; some of the sections are colored in carminate of ammonia, others are not; they are then washed in alcohol and cleared up in oil of cloves, gently heated to about 115° Fahr., in order to dissolve, from the specimen, all adherent particles of the paraffine cast, and mounted in Canada balsam. After the application of the oil of cloves they are ready for examination, and even the finest structure of the endothelium will be easily seen, without any previous treatment either by nitrate of silver solution, or by any other agent.

THE ARTERIES.

Obersteiner, in concord with other observers, distinguishes in the arteries of the brain, except in the arterioles, four different layers of tissue, viz., the endothelium, the membrana fenestrata, the tunica muscularis and the lymphatic sheath.

The endothelium represents a very delicate membranous layer in which, after treatment with nitrate of silver, the single cells composing the membrane, are distinctly brought to view; the nuclei are oval or bone shaped, their longitudinal axis being placed in the axis of the vessels. When the membrane has been insulated, the nuclei seem to be attached to spindle shaped cells, with long processes; which appearance, however, according to the author, is only due to foldings of the very delicate membrane itself. The endothelium is attached to a firm, compact, elastic layer of tissue, the membrana fenestrata, which exhibits a marked tendency to forming longitudinal folds. It contains no nuclei and shows no cellular structure, but is covered with numerous shining points, holes or perforations. It is much

diminished in the smaller arteries and disappears entirely in the arterioles.

Intimately connected with the *membrana fenestrata* are the circular muscular fibres, which form the third layer, the *tunica muscularis*. In its outer layers this membrane appears remarkably crenulated from projecting muscular fibres. While the larger arteries contain several layers of the fibres, the smaller vessels exhibit but one, and in this, the single fibres are shorter and broader. But loosely connected with the *tunica muscularis* and forming an entirely independent sheath, is the fourth membrane, the *adventitia*, or the adventitious lymphatic sheath. It can be easily removed, and contains round and oval nuclei. Frequently the sheath, when wide enough, appears to be arranged in wave-like parallel folds, which resemble bundles of connective tissue fibres, so that it seems as if a layer of connective tissue fibres had been inserted between the *tunica muscularis* and the adventitious sheath.

So far, we have stated the views of Obersteiner regarding the structure of the cerebral arteries. It is not long since, through the discovery of the cellular structure of the capillaries and the endothelium by Ebert, the fourth layer has been added to the three membranes supposed to compose the wall of the arteries, the *intima*, the *media*, and the *adventitia* of former times. At present, on the ground of my own observations, I must claim for the larger arteries, the existence of at least six, probably seven different layers.

All the main arteries of the spinal cord and the brain, and their branches, exhibit in general, the same structure. The endothelium, in the larger vessels, consists of a double layer of epithelial elements. The innermost layer is formed by peculiar low cylinder epithelium cells, with round nuclei. They are in health, of

a very fine and delicate structure, slightly oval shaped, generally slightly convex in their direction towards the lumen of the vessel, and flattened at the base. They are not ciliated, but frequently appear, instead of convex, excavated, resembling the so-called goblet cells. The second layer of the endothelium, to which the former is attached, is formed by long and narrow pavement epithelia with oblong nuclei; but in these much variety exists, so that they often, indeed, may resemble spindle shaped cells, as Obersteiner also seems to have observed. In the smaller branches of the arteries, which have entered the brain substance, and always after their first division, this pavement endothelium forms the only inner lining of the vessel.

The next layer, the *membrana fenestrata* is built up by an irregular, reticulated network, as shown in transverse as well as in longitudinal sections, presenting a web of broad, compact bands, with numerous foramina between them, differing in size and shape. The bands contain no nuclei, and show no cellular structure. This layer, characteristic of the arteries, varies much in dimension in the same specimen, and in the contracted vessel it generally appears denticulated. At its outer surface it is bordered by a uniform, tendon-like membrane, of quite a different nature, which resembles, in transverse section, a solid ring. It does not imbibe the carmine, and is of a shining appearance, and elastic, though no elastic fibres can be detected. It is connected only at intervals, and but loosely, with the fenestrated membrane. As it is only found in the arteries it must undoubtedly, by its peculiar formation, be regarded as a separate and the fourth layer of the same.

The fifth membrane is represented by the *tunica muscularis*, consisting of transverse unstriped muscular fibres, laid one over the other, interwoven with elastic

fibres, and in whose interstices, flattened lenticular corpuscles are embedded. The muscularis, in transverse sections, forms the most extended of all the layers of the vessels. It is but loosely connected with the fourth layer, but intimately passes over into the sixth layer, formed by separate large bundles of elastic fibres. This layer has also been overlooked by Obersteiner, who has confounded it with the supposed foldings of the adventitia, the author's lymphatic sheath.

The tunica adventitia, the now seventh membrane of the arteries, has recently been more subjected to discussion than any of the others. My own observations, however, do not sustain the correctness of the view, now generally received, regarding its nature as the enveloping membrane of an independent lymphatic system. This view would involve, as pointed out by Recklinghausen, the endothelium nature of the cells composing the sheath, which, as regards the adventitia of the arteries is entirely wrong. The membrane is built up of broad, fibrous, connective tissue elements, spindle shaped cells with long prolongations, and large, slightly oblong nuclei in the outer, and smaller round nuclei in the inner layers of the same. It is furthermore not true that the adventitia in health contains free cell formations of a lymphatic nature. This is very clear in transverse sections, especially when compared with the adventitious tunic of the veins and its contents, both of which are of a very different nature. In longitudinal sections, or when examined as a whole, may not the abundance of the large transparent nuclei and deposits of various kinds, even in health, have erroneously been taken for lymphatic elements? But even if in the adventitia of the arteries occasionally, free corpuscles, similar to those of the lymphatic fluids should occur—and nobody, I think, can furnish the proof that each artery of the brain is provided with an adventitious

sheath containing such bodies—could not these just as well be extravasated colorless blood corpuscles? Upon the ground of all that has hitherto been published on the subject, and from all the illustrations given in drawings, I must deny that any true evidence of the existence of an independent lymphatic sheath around the arteries of the spinal cord and the brain has ever been given. In diseased conditions of the vessels the adventitia may appear much distended, dilated and altogether altered; it may loosely envelop the contracted or stenosed vessel, but even here transverse sections through the whole organ will leave no doubt as to its true nature and structure. When Obersteiner says that he has observed an artery with one, and even two veins, inclosed in a common lymphatic sheath, he may be correct, as this might occur when the vessels are situated close together, a *lusus naturæ*, the possibility of which can certainly not be denied, but regarding the main question it proves nothing.

THE VEINS AND THE CAPILLARIES.

In the veins of the brain Obersteiner distinguishes three layers, and in the capillaries two. The epithelium or endothelium of the veins is similar to that of the arteries, but the nuclei are not so regularly situated, and more spherical; the cells of the arteries also are longer and narrower. This endothelium is intimately connected with the second layer, which, according to the size of the vessel, consists of a more or less extended connective tissue layer, with numerous irregularly situated round nuclei; single unstriated muscular fibres also occur, especially in the larger veins. The lymphatic sheath has the same appearance as that of the arteries.

The capillaries finally consist of the delicate endothelium membrane loosely enveloped in the lymphatic

sheath. This, however, has required a greater firmness than in the arteries and in the veins. The lymphatic sheaths, therefore, surround the whole vascular system of the brain, like a uniform and wide envelop, which is nowhere in connection with the subjacent layers. Between both layers there is a free space, the adventitious lymphatic space, or the lymphatic canal of Virchow and Robin.

The lymphatic sheath is not intimately connected with the adjacent brain tissue. Between them, in the normal state, considerable spaces are left, which likewise belong to the lymphatic system; these are the lymph ducts of His. They are not lined by a separate wall; the latter is formed by the tissue of the brain itself, and they empty into all the ultimate and minute fissures of the tissue, by which they are likewise brought in connection with the pericellular spaces.

The endothelium of the veins of the nervous centers, according to my own observations, consists, similarly to that of the arteries of the two layers of cells, differing in nature, viz: low cylinder cells and pavement epithelia. Their arrangement and the cells themselves are microscopically exactly the same as in the arteries. The third layer, greatly variable in dimensions, is built up of elastic fibres, and the fourth again of long and broad pavement epithelium, with comparatively small nuclei.

This is a double membrane, not closely connected with the subjacent layer. It contains invariably a large amount of lymph-corpuscles, and can but be considered as a true lymphatic duct. In transverse sections this adventitious layer is so markedly different from the corresponding adventitia of the arteries that I hardly understand how this could be overlooked. The sheath extends, however, more delicate in its structure, over the larger capillaries, while the smallest branches of these are not provided with any envelop. These latter

are directly embedded in the nervous tissue itself, and of such small dimensions that they allow only the passage of single blood corpuscles, which attain, compressed by the walls of these ducts, an oblong form. It seems, therefore, justifiable to me to distinguish between two kinds of capillaries, the one belonging mainly to the venous system, the others to the arterial system, a conjecture which, perhaps, is of practical importance for the understanding of some physiological relations connected with the nutrition of an organ, in which the change of matter must reach its highest point of action. It can not longer be doubted, since we are in the possession of the brilliant experiments and analyses of Pflüger on this question, that the consumption of oxygen takes place only in the tissues by the cells themselves, to which the red corpuscles of the arterial blood, charged with oxygen, transmit this agent of all life and life action. In the insects where the circulatory apparatus is most imperfectly developed, where no capillary system exists, we know that the finest ramifications of the air passages empty into the organs of the body themselves, so that the air is brought into direct contact with the cells. In the higher developed animals it is the hæmo-globin of the red blood corpuscles to which this duty is allotted, and it would, therefore, be very difficult to explain how this could be performed when the finest ducts in which these corpuscles circulate were separated from the tissue by an enveloping sheath containing lymphatic fluid. There are still a number of other physiological, as well as pathological conditions, which permit of an easier explanation by a conjecture based upon an anatomical fact, but in an article of this character I must forego the pleasure of entering upon a further discussion of the subject.

(TO BE CONTINUED.)

THE STRUCTURE OF THE VESSELS OF THE NERVOUS CENTERS IN HEALTH, AND THEIR CHANGES IN DISEASE.

BY THEODORE DEECKE.

II.

In a former article in this JOURNAL,* I gave an account of the normal structure of the vessels of the nervous centers. I now proceed to a discussion of the circulatory movements in the cranial cavity. Since the untenability of the old Monroe doctrine, that the amount of blood circulating in the cranial cavity, could not vary so long as the unelastic walls of the skull were not injured, has been demonstrated, experimentally, by Burrow, Donders, Kussmaul, Leyden, Ackermann and Jolly, we look upon the changes in the relative amount of blood, as well as in its aggregate quantity in the brain, just as in any other organ of the body. Notwithstanding this, however, we find arrangements in the central organs for the purpose of regulating the circulation, and of compensating the same, to a certain degree, when the variations exceed the normal standard, which are peculiar to the organ. There is, in the first instance, the cerebro-spinal fluid, discovered by Cotugno, 1764, who saw the fluid filling out the whole sheath of the spinal cord, from the foramen magnum downwards. He placed its site in the arachnoid sac, and he suggested the existence of a communication of this fluid with the contents of the cavities in the brain, through the fourth ventricle, and the aquæductus Sylvii. In 1825 Magendie re-discovered

* Vol. XXXIV, page 18.

the fluid, the existence of which was almost entirely forgotten. He was already fully aware of its physiological significance. According to him and to later investigators, the cerebro-spinal fluid is located between the dura and the pia mater in the sub-arachnoid space. Its quantity amounts to from two to three ounces, and it represents a clear fluid, marked by the small amount of albumen and saline matter which it contains, in comparison with other serous fluids. Magendie ascribed to it the important function of producing a uniform and continuous pressure upon the central organ; a view that in general has been sustained. Leyden* found the pressure equal to from ten to eleven centimeters of water; the pulsatory elevations of the column of water were about 0,4 ctm, the respiratory two to three ctm. These figures show that the pressure is indeed a positive one. It can not, therefore, be surprising that the removal of this fluid was marked by more or less severe symptoms. Cl. Bernard† found that a slow evacuation produces only slight disturbances, as long as the issuing fluid is replaced by air. By the use of an aspirator, however, and by excluding the air tremor developed, which was followed by convulsions and paralytic symptoms. The autopsy revealed a dilated axis canal, small apoplectic foci, and a swelling of the whole substance of the cord. Bernard concludes from this that the fluid serves as a regulator for the circulation in the spinal cord, and that it counterbalances the pressure in the vascular system. With the evacuation of the fluid by the aspirator, under the exclusion of air, the positive pressure was converted into a negative one, which fully explains the pathological alterations referred to. Other

* Ueber Hirndruck und Hirnbewegungen, Virchow, Archiv XXXVII, pag. 519.

† Leçons I, pag. 475.

points of interest are the pulsatory and respiratory movements of the cerebro-spinal fluid. Magendie speaks of these in the following words:

“The sinuses of the cranial cavity, and those of the spinal canal, differ essentially from each other in regard to the physical conditions of their walls. While those of the cranial cavity, of certain dimensions, are not subjected to a variation in the lumen, those of the spinal cord do not resist an alteration of their volume. Tension and rigidity is the character of the former ones, elasticity that of the latter. In the moment of expiration the sinuses of the spinal cord swell and produce a pressure upon the dura mater in the direction towards the cord. We know that the space between the spinal cord and the dura mater is occupied by a liquid; the pressure upon the dura, therefore, is a pressure upon this liquid. What will be the consequence? The liquid will give away in the direction where the resistance is the smallest, it will, since there is no obstruction whatever, enter the cranial cavity. The sinuses of the brain are not dilated, because their walls do fully counter-balance the pressure from the venous blood. The cerebral fluid is exposed to a lower pressure than the spinal, the surplus of the latter will force the fluid into the cranial cavity.”

These ingenious views of Magendie are in general adopted by physiologists. Unexplained, however, remains the origin of the fluid, and its closer relation to the vascular system of the nervous centers. Against the theory of a simple exudation, caused by the pressure of the blood, is opposed its composition, which so widely differs from that of other hydropic liquids, and, by the same reason, a direct communication with lymphatic vessels must be denied. Besides, neither the one or the other theory would account for the actual or positive pressure, which the fluid exerts. There remains, therefore, only one suggestion, that is, to regard the cerebro-spinal fluid as a product of secretion of a serous membrane, of the arachnoidea itself, and perhaps of the serous membrane which lines the axis canal of the spinal cord and the ventricles of the brain.

Regarding the actual relation of the cerebro-spinal fluid to the movement of the blood in the vessels which penetrate the central organs, it must be kept in mind, that the substance of the brain and the cord are incompressible. The aggregate quantity of blood, therefore, which at a certain time is in circulation, and the relative amount of arterial and venous blood can only be regulated by arrangements in the structure of the vessels themselves. It is generally accepted that the so-called lymphatic sheath, or the perivascular lymph-spaces, by which the cerebral vessels are claimed to be surrounded, serve as regulators. When the cerebral vessels become distended, a corresponding quantity of the contents of these spaces is displaced, and, conversely, the diminution or the abstraction of blood from the vessels is concomitant with a filling up of their lymphatic envelops. Although there is not yet anything definitely known of the communications of these lymphatic ducts with the sub-arachnoid spaces, the ventricles, etc., and the lymph-glands of the head and the neck, some evidence has been given that such connections do exist.

Gaethgens found, that through an injection of defibrinated blood, under high pressure, into the carotid, the lymph could be made to flow rapidly out of the lymph-vessels of the neck.

Against this theory of general connections, there has only one fact been brought forward, that is, as has been mentioned above, the remarkable difference in the chemical composition of the cerebro-spinal fluid, and of the liquid contained in the lymphatic ducts. Besides, however, it should not be forgotten, that in the former, no organized lymphatic elements have been observed. This awakens the suspicion that the arrangements are not quite as simple as accepted.

In the first part of this paper* I have called at-

* Loc. cit. page 23.

tention to some differences in the structure of the so-called tunica adventitia of the arteries and the veins of the nervous centers, which have not yet been taken into consideration. It is only the tunica of the veins which exhibits, in its endothelial structure, the character of a true lymphatic duct, while that of the arteries is built up of other material, of broad, fibrous connective tissue elements, spindle-shaped cells, with long processes, and large, slightly oval nuclei in the outer, and smaller round nuclei in the inner layers of the membrane. This latter, also, does not contain, in health, any free cell-formations of a lymphatic nature. More recent investigations, made on transverse sections through the whole brain, with its membranes, have confirmed these statements. They show that indeed, only the spaces surrounding the veins, are direct continuations of the lymphatic ducts of the pia mater, while the enveloping membrane of the arteries does not stand in communication with the same. This difference is very striking in large sections, examined even with low powers, which permits bringing quite a number of vessels, entering the grey cortex in the field of vision. The funnel shaped mantle of the veins will be found almost always extended, sometimes densely packed with lymph corpuscles, while that of the mostly contracted arteries, either loosely envelops the vessel, or in a collapsed condition, firmly adheres to the muscular coat.

Proceeding now from these anatomical facts to their physiological significance it would appear not unreasonable to modify the views, hitherto advanced, in regard to the roll which these adventitious membranes and their contents play in the circulatory arrangements of the central organs. The condition of the tunica adventitia of the arteries, and its relation to the proper walls of the vessels, demand the assumption that during life

the space formed by it between the elastic walls of the vessels and the organ itself, must be filled out by a liquid body, which counterbalances the pressure of the blood inside the vessels or gives away to it. As now, according to the anatomical relations, these spaces do not communicate with the lymphatic ducts, it seems not to be out of the way to presume the existence of a connection with the cerebro-spinal fluid, and this seems to be the more acceptable, as only by this arrangement the pulsatory movements of this fluid can be explained. We have, therefore, two regulators of the circulation in the central organs, to a certain degree independent of each other, the one belonging to the arterial, the other to the venous system, the importance of which will be fully appreciated, when we consider that by this arrangement the whole capillary system, from all deviation from the normal state, which may occur in the one or in the other direction, will be affected only in the second or the third degree. The principle, condensed in a few words, will be the following: an increase of arterial blood will be attended by a displacement of the cerebro-spinal fluid and, in certain limits, even an elevation of the intercranial pressure may be produced without involving any changes in the normal venous afflux. The venous stasis will be concomitant with a displacement of the contents of the lymphatic spaces, yet without a retardation of the arterial afflux.

The application of this principle to pathological condition will be the object of discussion in a later article. It remains here, for the sake of completeness, to refer to some further arrangements which have been called up for the purpose of explaining other phenomena connected with the regulation of the intercranial circulation, the influence of which undoubtedly must be acknowledged. According to Maingien and Guyon the

thyroid gland is claimed to furnish means for the regulation of the cerebral circulation. When, in consequence of excessive muscular exertion, the veins of the neck become compressed and danger arises of a venous congestion in the brain, the gland, increased in size by this occurrence, is said to press against the carotids, and to diminish, consequently, the flow of blood through them, and to remove in this way the cause of a further distention of the intercranial vessels.

Schröder v. d. Kolk,* from the result of injections, believes that in the pia mater a direct communication exists between the arteries and the veins by anastomoses, so that the passage of the whole amount of blood through the capillaries of the brain substance is not rendered absolutely necessary. This has not yet been confirmed, but Heubner† found that the arteries of the pia mater form a network of anastomoses in such a manner that there exists a free communication between all parts of the membrane, an arrangement by which a compensation in cases of local deviations from the normal state must be facilitated. And Heubner discovered furthermore that the arteries form a second network before they send off branches into the cortical substance of the brain. These anatomical conditions, of course, would add greatly to the protecting arrangement with which the central organs are supplied.

(TO BE CONTINUED).

* *Geisteskrankheiten*, pag. 52, 91.

† *Die Luetischen Erkrankungen der Hirnarterien*, Leipzig, 1874.

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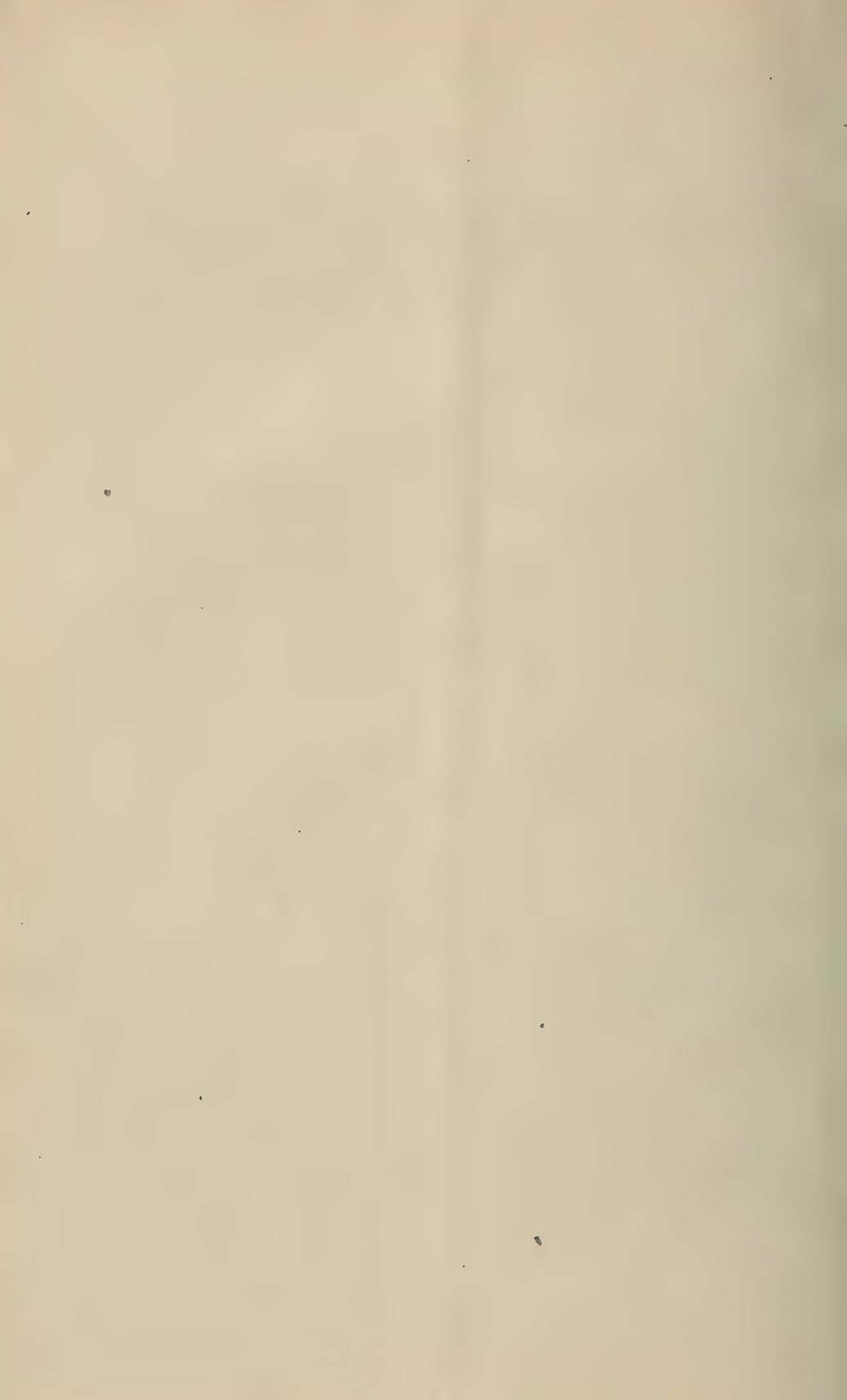
The Structure of the Vessels of the Nervous Centers in Health, and their Changes in Disease.

PART III.

By THEODORE DEECKE,

Special Pathologist, New York State Lunatic Asylum, Utica.

From the *American Journal of Insanity* for April, 1879.



THE STRUCTURE OF THE VESSELS OF THE NERVOUS CENTERS IN HEALTH, AND THEIR CHANGES IN DISEASE.

BY THEODORE DEECKE.

III.

In the foregoing articles we have seen that peculiar vascular arrangements exist in the membranes of the nervous centers. It will not be surprising to meet with more peculiarities when we dissect the organ itself. The fact that the arteries of the arachnoidea and of the pia mater form two networks of anastomoses, before they send off branches into the substance of the brain, was discovered by Heubner, and must be sustained in opposition to the objections of Duret,* who admits only anastomoses between the finest vessels of neighboring territories. Another fact has been recognized long ago, that the arteries penetrate the brain commonly to a considerable depth before they divide. H. Duret† found it necessary to make the size of the arteries a point of distinction and describes their distribution as follows: The grey cortex is supplied only by those of small caliber and they terminate there in narrow meshes of capillaries, thus forming small territories of nutrition. The larger stems do not break up into ramifications before they have reached the medullary layer, and they supply mainly the white substance, taking a course generally parallel to the course of the

* Recherches anatomiques sur la circulation de l'encéphale. Arch. d. Phys. norm. et path, 1874.

† Op. Cit.

nerve fibers. In the grey cortex three districts can be distinguished, one with a capillary network of comparatively large meshes in the external layer, one of very small polygonal meshes in the ganglionic layer, and one again of larger meshes at the border of the white substance. All these statements are in part correct, yet they can not claim to give full expression to the plan of organization. There are other points which must be considered of importance.

For the purpose of delineating a picture of the vascular arrangements in the substance of the brain, it seems the most acceptable to me to distinguish between four territories, viz.: the external layer of the convolutions, the ganglionic layer, the medullary substance, and the grey central nuclei or the great ganglia.

The nature of the external layer of the convolutions seems not to be beyond discussion. The description and illustration of the same in our text-books, and in other publications, are still very imperfect and diagrammatic. One of the best illustrations is found in Henle's "*Nervenlehre*, I, pag. 274;" the description, however, does not correspond with the drawing. I at least, can not detect there any star-shaped connective tissue cells, which, according to the text, the layer is said to contain. The peculiar triangular bodies in Meynert's diagram are the result of a false interpretation, and their form is to be explained from the various positions of these bodies in the sections. According to my own examinations of large sections through the whole brain, which offer the advantages of presenting the most various aspects of the object in one specimen, the layer contains a limited number of round nuclei, but in the main its framework is built up of delicate fibers which represent the manifold inter-woven, processes of star-shaped connective tissue corpuscles. The tissue is destitute of

nerve cells and also of nerve fibers, which are in connection with the subjacent ganglionic layer. It must simply be considered as a protecting cover of neuroglia tissue. From its wide meshy, or reticulated structure we can conclude that it is elastic, or to a certain degree compressible. It is not separated from the subjacent ganglionic layer, but merges imperceptibly into the same. If, however, under low magnifying powers, large areas are brought into the field of vision, the differences in the structure appear so striking, that a distinct line of demarkation between the layers will be visible.

The surface of the layer toward the pia mater is bordered by a layer of longitudinal fibers parallel to the convexity of the convolutions. I have not yet been successful either in dissecting the same into single elongated spindle-shaped cells, or in demonstrating their connection with the fibrous processes of the connective tissue corpuscles of the subjacent tissue. It must also remain an open question whether the layer is covered or not, by a delicate pavement epithelium, or by endothelium. Regarding its relation to the vessels which enter into the cortex of the brain, it must be remarked that the fibers form simple concentric openings through which the vessels take their course, and that they do not conduct the same downwards. The latter fact would speak against the existence of a lining by endothelium.

The external layer of the convolutions receives its vascular supply mainly from quite small branches of the second arterial network of the pia mater, which in a right angle enter into its tissue and, at once, break up into ducts of small caliber. This is the rule. Occasionally a larger stem, on its way downwards may send off a branch, or one of the smaller may enter the gan-

glionic layer. The tissue does not abound in capillaries, but their caliber is always larger than that of the capillaries of the ganglionic layer. The whole thickness of the external layer of the convolutions in sections through a human brain, carefully hardened in chromic acid solution from one-fourth to one-half per cent and alcohol, is in the average 0,011 inches, of which 0,0007 inches belong to the fibrous lining. These figures, of course, are correct only for sections cut exactly in a right angle to the tangent of the convolutions. A difference in thickness in different convolutions from 0,1 to 0,3 millimeter, as pointed out by Henle, has not been observed by myself. The round nuclei in the tissue, of which two kinds are to be distinguished, from their size as well as from their appearance, measure 0,0003 and 0,00016 inches in diameter. The larger ones contain a granular protoplasm, the small ones a nucleolus which fills out almost the entire lumen of the cell. Both cells are found only in limited numbers and irregularly distributed through the tissue, the smaller ones occur more frequently in the fibrous covering.

The most interesting organizations in the layer are the connective tissue corpuscles. They are described by Henle as very small stellate cells, the fibrous processes of which are in connection with the delicate network of which the layer is composed. This description is, in general, correct. According to my own observations the body of the cells has a diameter of from 0,0003 to 0,0004 inches. They are nucleated, and their tooth-like projections, five to ten in number, have a length of from 0,00015 to 0,0002 inches. Each of these projections runs out into a delicate fiber of 0,0019 inches or more in length, and the largest distance between the corpuscles amounts to from 0,0009 to 0,0013 inches.

From this it will be seen that these corpuscles are of considerable magnitude, that they are not sparsely scattered, and that the tissue is far from being destitute of cells, as generally described by authors. It is probably from the circumstance that they imbibe the carmine solution so very slowly that their presence has been frequently overlooked. In sections which had remained from six to ten days in the staining fluid they became most clearly visible.

The second territory of nutrition which we have to consider is the ganglionic layer of the convolutions. It receives its vascular supply from the first network of anastomoses in the arachnoid spaces, from arteries of considerable size which penetrate the cortex of the cerebrum down to the border between the grey matter and the medullary substance, before they divide. I do not fully agree with Duret, who separates this territory entirely from the following—the medullary layer. The main supplying vessels for both districts are the same, yet the manner in which they break up into fine ramifications is a point of difference, and justifies a distinction between the two, and a separate consideration.

The vessels, as a rule, after having reached the lower district of round cells, which separates the ganglionic layer from the medullary substance, send off branches at a right angle. If divisions occur above this point they are at an acute angle, and it is not unfrequent that two vessels, almost of equal caliber, are observed in the same perivascular canal. From the rectangular branches others proceed in an upward direction—that is, from the internal toward the external layer, which abruptly break up into that fine and dense network of capillaries by which the ganglionic territory is characterized. The main stems, however, proceed in their course downward into the white substance, where they

again divide, commonly at more acute angles, and where the main stems themselves gradually diminish in size, and obtain a capillary appearance. From this arrangement it occurs that, although both territories receive their blood supply from one and the same source, in the ganglionic layer the districts of nutrition appear to be very small, with a limited longitudinal, and a small lateral extension, while in the white substance, the meshes of capillaries are wide and prolonged and follow the course of the fibers. This arrangement seems to be physiologically of importance.

There are two principal factors which come into consideration, viz.: the pressure of the blood in the nutritive vessels, and its physiological variations. In regard to the relative pressure, we know that it diminishes, in a direct ratio, to the transverse diameter of the vessel; but a marked difference will be noticeable, according to the manner in which, in a given case, the division into smaller branches takes place. According to the physical laws of the movement of fluids in elastic tubes, there is much less resistance and loss of pressure when the transition into tubes of smaller caliber is a gradual one, than when there is a sudden breaking up. In the latter case the pressure in the capillaries, for instance, will be but a minimum of that in the mother vessel. From microscopic observations of the circulation of the blood in living tissues, we must draw the conclusion that in the capillary system in general, even in tissues which are not prominent for their vascularity, the actual pressure is exceedingly small, frequently so small that the weight of the cover glass suffices to interrupt the circulation.

Both conditions now—the sudden division and the division into ducts of the smallest caliber—are a prominent feature in the structure of the ganglionic layer of

the convolutions of the brain. From this we must conclude that the pressure of the blood in the nutritive vessels of this delicate and sensitive tissue can be but very low and uniform. From the abrupt origin of the capillaries in this tissue we must, furthermore, conclude that the circulation in the same is in a high degree protected against influences dependent upon alterations of pressure in the larger supplying stems. This protection, it is true, seems to be less effective in regard to sudden and violent changes, which, considering the low pressure in the capillaries, may immediately result in a temporary stasis of the blood of more or less extension, an affection to which the grey cortex of the brain appears to be exposed to a high degree. Under otherwise normal circumstances, however, there will always be a quick relief from this condition, since the arteries do not terminate in these districts. There is free afflux of the main current, enough to prevent a continued interruption.

We proceed to a consideration of the second factor—the physiological variations of the pressure of the blood in the nutritive vessels. It is customary to assume that all modifications of function are intimately connected with changes in the supply of blood. This proposition has been affirmed by science. Thus we speak, in a physiological sense, of cerebral hyperæmia, that is, of an increase in the supply of nutritive material during mental activity, and of cerebral anæmia, or a decrease in the supply during rest. It is not intended by these words to explain anything in regard to the physiological difference between the state of being awake and sleep; it is simply a statement of an existing relation between the demand for, or the consumption of material, and its supply. The question arises, what is the nature of this relation? The unprejudiced answer would

be: it is the demand, or the consumption that regulates the supply; or, in other words, it is the life-action of the tissue which alters and regulates the supply. This, indeed, seems to be quite natural, and in conformity with the oldest and the newest theories of the processes of nutrition. This, I think, explains in a satisfactory manner all the physiological changes in the nutritive system which are supposed to occur continually.

Recently, however, the hypothesis has been advanced of the existence of a system of so-called trophic nerves in the body. They are considered, like the vaso-motor nerves, as a part of the sympathetic system, and it is said that it is their function, by chemical action upon the tissues, to control their nutrition. We will learn in the following what the consequences of this supposition would be.

It appears somewhat singular that at the present time this hypothesis only claims to serve for the purpose of explaining pathological conditions, or conditions brought about by a forcible intervention with the normal state of things. That it adds anything to a successful understanding of the processes of the continual change of matter, to which all the tissues of the body are subjected, can not be asserted. It does not throw any light upon the great variety of these processes, from a chemical point of view, nor upon their nature, which has hitherto been considered as intimately connected with the active life of the tissues, or, in the last instance, with its cell elements. Does it not seem hazardous to make the individual or the family life of all the cells of which the organism is composed, so different in nature and destination, dependent upon an outside factor? If the nutrition of these cells is controlled by such a factor, the action of a trophic nerve, what, we

may ask, controls its own nutrition? It is out of consideration that the organic change of matter is a chemical process, and that a deviation from the normal standard of assimilations and dissociations, in a given case, indicates the presence or the absence of some factor, by the influence of which this is produced. But it has never been suggested to look for this factor in other quarters than in the constitution of the chemical compounds or elements which act upon each other, or in the constitution of the organized elements by which this action is maintained and modified. The ultimate laws of life and life-action are not yet within the limits of our cognizance, but to place the physical or physiological properties of membranes, of the protoplasm, of the nucleus of a cell in a state of dependence to nerve force, which itself very probably originates in organic chemical actions, does not signify any progress towards the discovery of those laws.

The fundamental phenomena upon which the theory of the existence of trophic nerves was based, are the same from which the existence of a vaso-motor system was deduced. If the sympathetic nerve or a branch of it, leading to a part of the body is divided or destroyed, the blood vessels of that part immediately lose their tonus and become enlarged. If, however, a galvanic current is caused to pass through that part of the nerve which is still in connection with those vessels, they immediately contract, and in a direct ratio to the strength of the current, even beyond their normal expansion. Cl. Bernard, who discovered this fact, found furthermore, that the dilatation of the vessels was concomitant, aside from an increased fullness, with an elevation of temperature in the part affected, while the contraction was accompanied by a pale, anæmic condition and a diminution of the temperature, even below

the normal standard. The contraction of the vessels was regarded by all as an active phenomenon and led at once to the acknowledgment of a vaso-motor system of nerves, and to further successful investigations for the purpose of determining their mode of division and the location of their center. The phenomenon of the dilatation of the vessels may, and has been differently explained. Brown-Séquard and other prominent physiologists considered it as of an entirely passive nature, as a paralysis, produced by the interruption or cutting off of the tonic nerve from its center, following which, the relaxed walls of the vessels yielded at once to the expanding pressure of the blood. Against this explanation there can hardly anything be brought forward, and it is the one at present generally accepted.

In regard to the accompanying phenomenon, the rise and the fall of the temperature in the affected parts, it seems to me that a misinterpretation has existed from the beginning up to the present time. The simplest explanation undoubtedly would be, that the changes in the temperature have a direct relation to the changes in the velocity of the blood current and its consequences. These are an increase or decrease of friction, or heat, which necessarily results from the acceleration or the retardation of the current of the blood. The importance of this factor, and the degree in which it should be brought into account, can be estimated from the alteration which it produces in the walls of the vessels themselves. These alterations take place long before any influences upon the surrounding tissues become noticeable, and it appears very questionable whether it is at all necessary or justifiable to have recourse to other sources, for the variations in temperature, than those furnished by the vascular system itself.

Nevertheless, this has been done from the beginning. The increase or the decrease in the fullness of the vessels, the hyperemic or the anemic condition was at once, not only brought face to face with, but was made equivalent to an increase or decrease in the vital activity of the parts involved. Thus the elevation and the diminution of the temperature was made an indicator, not of changes in the supply and its natural consequences, but of alteration in the changes of matter, that is, of changes in the consumption of material. This admitted, it was only a small step further to conclude from the experiments, that in the case of the galvanic excitation of the sympathetic, like the current of the blood, the change of matter in the part in question, or the consumption of material, was impeded by the action of nerves belonging to that system, and that it was accelerated, like the current of the blood, in the state of paralysis of the tissues produced by the cutting off of those nerves from their center. The sympathetic was, therefore, considered as an inhibitory nerve in regard to the processes of nutrition; in a state of action it impedes and diminishes assimilation and secretion; it paralyzed the chemical processes exceed the normal bounds, or—all bounds.*

It is, however, not the capillary system alone, Schüle† continues, upon which the trophic nerves act; they also lower the functional activity of the tissues themselves.

We may look upon the theory of the existence of trophic nerves, in its present form, from any point of view we choose; the one suggestion, if the theory is true, must be accepted, that supply is equivalent to consumption. The tissues or the cells are compelled to

* Vide Schüle, *Mental Diseases in Ziemssen Cyclopædia*, pag. 612. German edition.

† Loc. cit., pag. 612.

consume, they must consume the more, the more material is furnished, even if they should perish, as long as the trophic nerves suffer, which, under normal conditions, by measuring the quantity of food they furnish, prevent a surfeit of the little stomach of the cells.

Schüle* assigns to the disorders of this trophic nervous system an important office in the pathology of mental diseases. The sympathetic is, in his opinion, the trophic nerve of the brain, and he sees in affections of the same the common physio-pathological point of contact between the nature of the two fundamental forms of mental disturbance: mania and melancholia. In melancholia, he says, the inhibitory power of the sympathetic, in regard to the act of nutrition, prevails. In mania, the change of matter in the tissues is accelerated by its inactivity. He finds an affirmation of these views in the "*pulsus tardus*," common to all neuro-pathic constitutions, from which the psychoses arise, viz.: melancholia, characterized by the trierotic *pulsus celer*, mania by the dierotic *pulsus celer*. In this he goes too far. The pulse curves give us a graphic picture of the periodicity in the changes of the blood pressure, but there is at present nothing known of the relation they bear to the state of nutrition of any organ of the body. The claim of Schüle, furthermore, that this view is quite in accordance with the definitions of Meynert, of melancholia as an exhausted condition of the brain, of mania as a cerebral disorder in which the liberation of vital energy is made easier, is likewise unproved, and only acceptable when we adhere to the same error, above exposed, considering the changes in the supply of nutritive material equivalent to alterations in the change of matter.

* Ibid, pag. 613-620.

This leads us back to our main question. The principle expressed in this sentence can not be brought into harmony with other established physiological facts. It was shown by Pflüger* years ago, experimentally, that the consumption of oxygen, by the tissues, undoubtedly the measuring indicator of all change of matter, of course in certain limits, is independent of the quantity contained in the blood, that is, independent of the supply. Some years later Finkler† demonstrated by a series of experiments that the consumption of oxygen, as well as the excretion of carbonic acid, is absolutely independent of the velocity of the blood current, the quantity of the blood furnished, that is again independent of the supply. In these experiments the variations in the supply of blood amounted to not less than one-third of the normal standard. This of course would locate the regulation of the change of matter entirely in the active life of the tissues or of the cells themselves.

But objections may be raised against the validity of these experiments in regard to their connection with the pending question. It can be said that the trophic nervous system was not injured in these experiments, and executed, in spite of all changes in the supply, its inhibitory power upon the activity of the tissues. But how is it, if, by the simple introduction of another factor, we were able to overthrow this power? This has been done by Bert,‡ who showed that, although the consumption of oxygen by the organism is independent of the partial pressure, this is not the case in

* Pflüger, *Archiv. für Physiologie*, VI, pag. 43.

† Pflüger, *Archiv.*, X, 7.

‡ *Recherches, experimentales sur l'influence que les changements dans la pression barométrique exercent sur les phénomènes, de la vie. Comptes Rendus*, 1873, 76, 77.

regard to its tension. If animals respire in an atmosphere of oxygen of high pressure, they will be affected with convulsions, at the moment when the arterial blood contains 28 to 30 vol. p. c., (0,76 m. pressure,) of oxygen, and they die in 35 vol. p. c. As this is equal to an amount of 22.8 p. c., and 26.6 p. c., by a pressure of one meter, it is evident that it represents only a small increase of the normal amount. This small increase, however, corresponds to an immense increase of the tension of the oxygen, about as 35 to 2280. In these experiments the consumption of oxygen and the formation of carbonic acid decreased in an inverse ratio to the pressure. The excretion of urea was diminished and the temperature lowered. There was, therefore, a great alteration in the change of matter; where was the influence of the trophic nerves to prevent these alterations?

In order to get a right idea of the importance of this discovery of Bert, it will be necessary to analyze the meaning of the word change of matter. It is evident that in the life of the tissues and the cells, we have to distinguish between two active principles, viz.: the assimilation of nutritive material, and the dissociation of the assimilated material. In the act of assimilation, the albumen, for nourishment, is converted into the living albuminous compounds of the cell. The first is characterized by its durability, its indifference and its power of resistance, the second represents the most decomposable and unstable substances. In the building up of a tissue, therefore, labor is performed, by which the cohesion of the albuminous molecules has become extraordinarily weakened. Heat is absorbed, and stored in the constitution of these living molecules; intramolecular heat, which can be considered as the physical expression for the inner life of the cell.

The contrary takes place in the acts of dissociation of the living albuminous compounds, under formation of carbonic acid, water and amide-like compounds. The intra-molecular labor is diminished and heat is liberated.

According now as the one or the other process prevails, there will be a change in the condition of the tissues. In normal life this change is a periodical one, and is regulated by organic laws, the nature of which, as we have good grounds to assume, must be intimately connected with, and dependent upon the nature and the functions of the cells, that is, upon the nature of the living albuminous compounds which constitute the cell organism. These laws must be different, for the cells of which the liver is built up, from those peculiar to the kidneys; different, for the fibers of the muscles from those for the fibers of the connective tissue; different for the ganglion cells of the spinal cord, from those of the grey cortex of the convolutions of the brain, etc.

It is unquestionable that these changes in the condition of the tissues have something to do with the states of so-called rest and activity, to which all living organic structures are more or less subjected. These changes seem to become the more marked, and characterized by their periodicity, the more complex the organization of the part and its functions. It reaches its highest point evidently in the state of sleep and of being awake, in that part of the nervous system in which, by good reason, we locate the laboratory for the play of those processes, which are invariably concomitant with the display of the intellectual faculties of the mind.

During rest or sleep, the inner labor, the processes of assimilation prevail, during activity or when awake, the processes of dissociation. In the first case heat is con-

sumed, withdrawn from the surroundings and converted into latent energy, or intra-molecular heat. The perceptible temperature is lowered. In the second case heat is liberated; the latent energy converted into living forces, transferred to and acting upon the surroundings. The perceptible temperature is raised. From this it will be seen that the actual rise or fall of the temperature in any part of the body is only conditionally an indicator of the rise or the fall of the change of matter in that part.

We will now fully understand the import of the phenomena connected with Bert's interesting experiments. It was only one factor in the change of matter, whose state of activity was affected; the dissociation of material. The affinity of the living albuminous compounds, of the cells of the body, to oxygen under high barometric pressure, was found to be more or less extinguished. The living albuminous compounds exhibited here the same conduct, as, for instance, active phosphorus, does. This element so easily oxydized under common circumstances, displays no affinity to *comprimated* oxygen, and is not oxydized in an atmosphere of the same.

If the results of these experiments demonstrate anything, they demonstrate that it is solely the life action of the cells themselves, which regulates the change of matter. The living cell *takes* the oxygen, as the phosphorus does, under certain conditions, as one of its active functions of life, and it is not compelled to do so by an outside factor or by the quantity which is offered to it for consumption. What is found to be a law, for one substance and that the most important one carried by the blood to the tissues, must be binding for all.

It must, therefore, be considered as one of the principal laws of life, that the change of matter is regulated in the living cells, and that it is not the quantity of

nutritive material, furnished, or the velocity of the blood current, which executes a determinative power upon these processes.

With the acknowledgment of this law, the existence of trophic nerves as parts of the sympathetic system, or the existence of nerves, or of a center, for the production or moderation of animal heat, has become, at least more than doubtful, and may be left entirely out of consideration, in regard to the circulatory movements in the cerebrum. After this excursion into a purely physiological domain, I recapitulate the results of our investigations.

The vascular arrangements in the ganglionic layer of the convolutions of the brain, which are physiologically and pathologically to be considered of importance, are:

1. Its separation, in regard to the origin of its supplying arteries, from the first, the neuroglia layer of the convolutions.

2. The mode of division of comparatively large stems, which arise from the first arterial network in the arachnoid, and penetrate the grey cortex, sending off the first branches at a right angle, in the lower part of the ganglionic layer, from which the finest networks of capillaries abruptly originate, supplying the layer with nutritive vessels in a direction from the lower sections upward.

3. The comparatively small territories of nutrition which are created by this manner of division.

4. The continuation of the main stems downward into the medullary layer, by which arrangement a free afflux of the main blood current is afforded, thus reducing the pressure of the blood in the nutritive capillaries to the utmost, and protecting the same in a high degree against persistent alterations in the circulation.

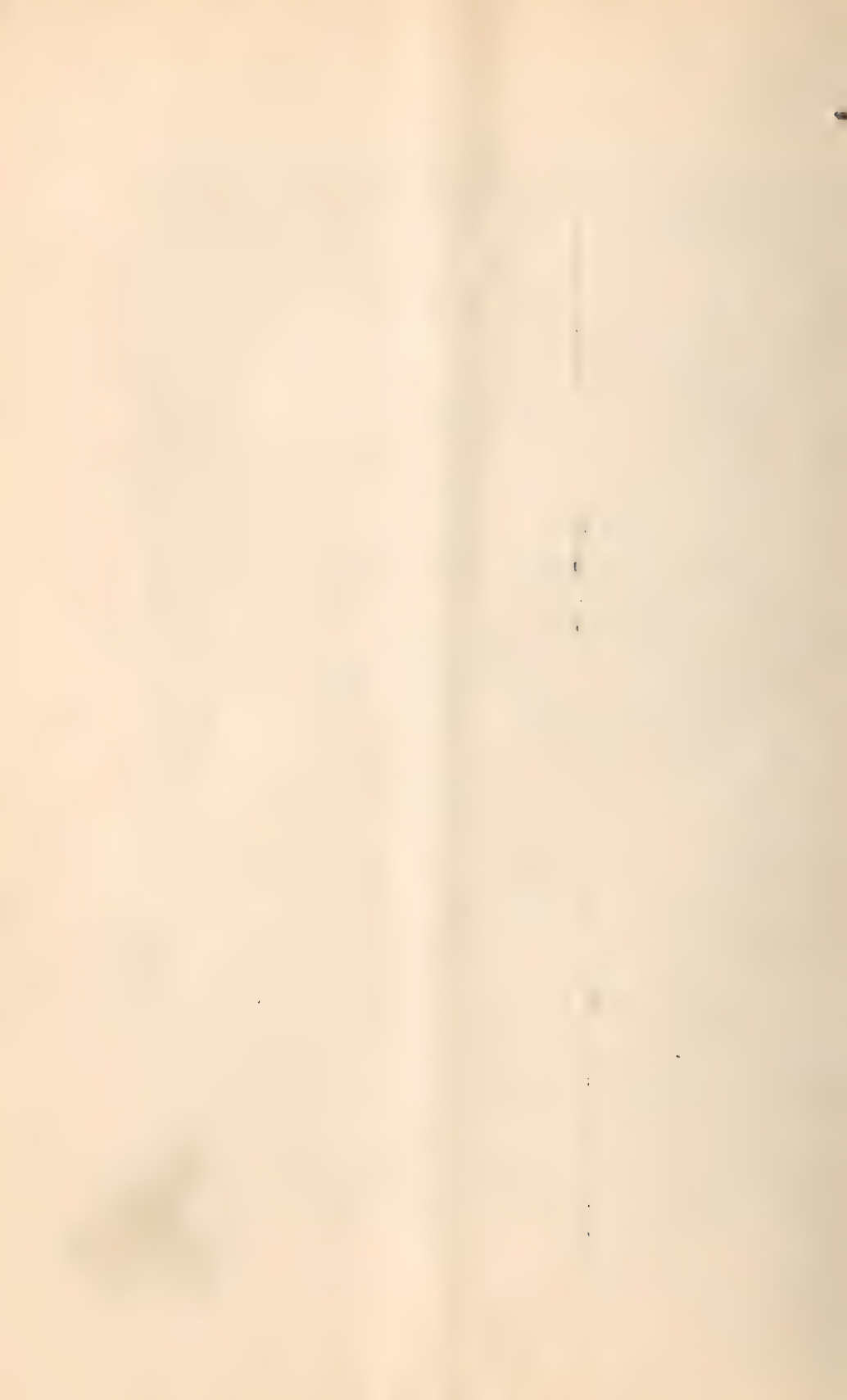
It may be remarked here that these arrangements are of course not without exceptions; yet they appear the more striking the more numerous and larger the fields are which we explore. The description given in the foregoing, is drawn from the study and comparison of a very large number of sections cut at the most various angles to the convex surface of the convolutions. Each section was made through the entire brain, with its membranes, thin enough for the use of objectives from one to one-fifth of an inch.*

The next vascular territory which comes into consideration is the medullary layer. It has been remarked in the foregoing that it receives its arterial supply from the same source as the ganglionic layer. The mode of division of the vessels, however, is a different one. As soon as they have entered the medullary layer they send off branches at acute angles, following the course of the nerve fibers, of which the layer consists. They gradually diminish in size, running out into arterioles, and finally into capillaries of which prolonged networks, with wide meshes, are formed, characteristic of this layer. This arrangement, in cases of congestion or hyperæmia of the brain, gives origin to the post mortem phenomena known as the "*puncta sanguinea*," in sections through the fresh organ. They represent red spots, at all places where blood vessels have been divided, which differ from punctiform hæmorrhages, in that they can not be washed away by a stream of water, while the latter can. Their number and size, and the rapidity with which, in a given case, they reappear, long ago served as a measure for the degree of congestion during the

*The instruments and methods employed were described in the JOURNAL OF INSANITY, for July, 1876. The former were manufactured to order by Philo S. Curtis, 214 Whitesboro St., Utica, N. Y., where they can be obtained.

last moments of life. The phenomenon has its physiological as well as its pathological foundation. From the gradual transition of the larger tubes into those of smaller transverse diameter, it follows that the pressure of the blood, also in the nutritive vessels of these districts, must be, at all times, higher than in those of the ganglionic layer. To this has to be added that the arteries are in fact terminal arteries in these districts. The medullary substance is, therefore, not so well protected against persistent deviations of the circulatory movements from the normal standard, as the grey cortex of the brain. It is in accordance with this fact, that all cerebral disorders, originating from vascular lesions, in the beginning are characterized simply by functional disturbances in the conductive elements of the central nervous system, and these may continue for a considerable length of time, before other symptoms arise which point toward a deeper affection of the organ in which the ganglionic centers of the brain are themselves involved.

(TO BE CONTINUED.)



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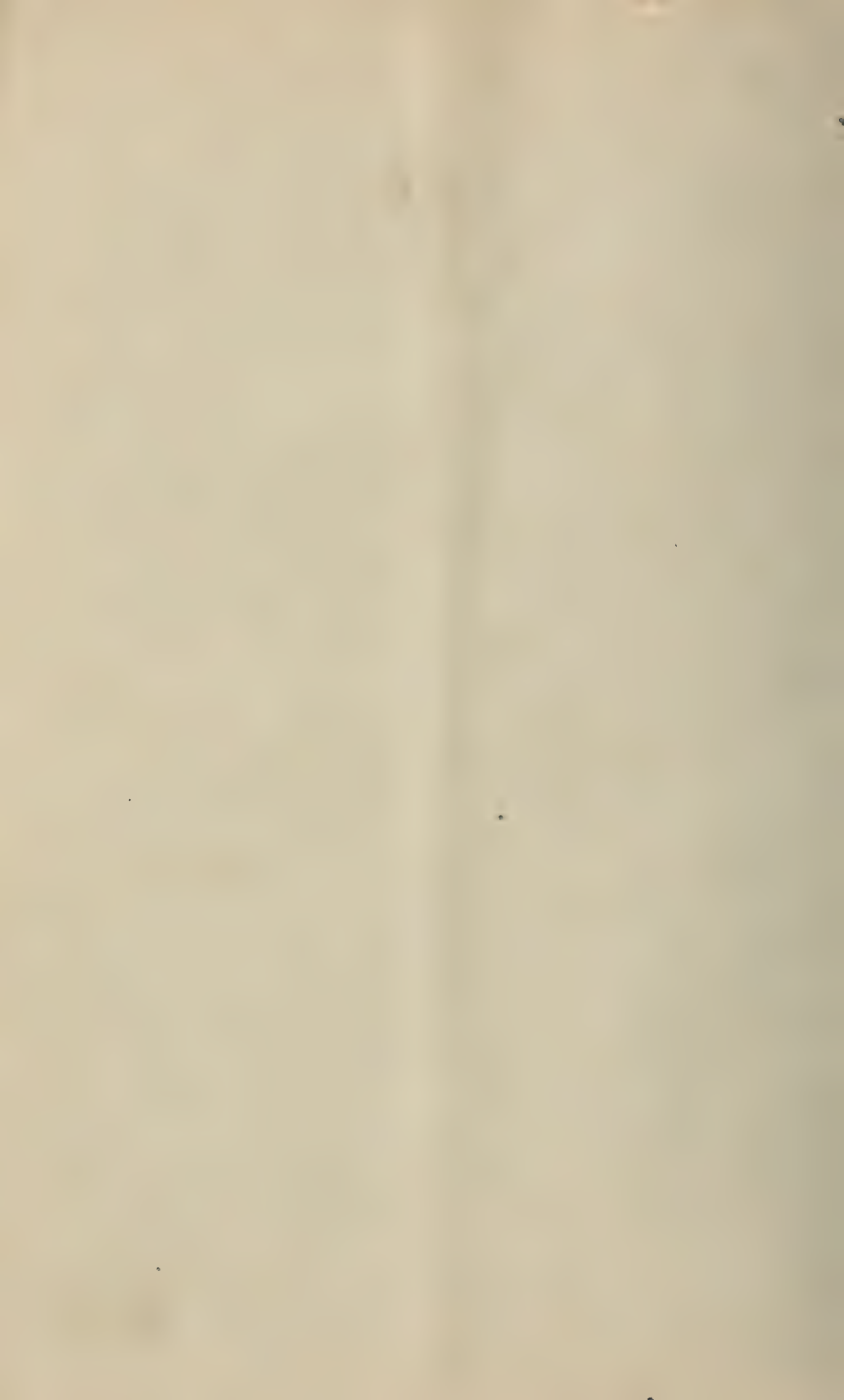
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The Structure of the Vessels of the
Nervous Centers in Health, and
their Changes in Disease.

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PART IV.
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By THEODORE DEECKE,
Special Pathologist, New York State Lunatic Asylum, Utica.

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From the *American Journal of Insanity* for January, 1880.

THE STRUCTURE OF THE VESSELS OF THE NERVOUS CENTERS IN HEALTH, AND THEIR CHANGES IN DISEASE.

BY THEODORE DEECKE.

IV.

We proceed to the description of the vascular arrangements in the central grey ganglia of the brain, including the ependyma of the ventricles, the internal capsule, the commissura beseosa alba, the laminae septi lucidi, the external capsule and the claustrum. It is well known that the central ganglia are, more frequently than other parts of the cerebrum, the seat of lesions of the vascular system; that intracephalic hæmorrhages are, in general, much more common in these centers than in the peripheral parts. It may, however, be remarked that this does not hold in reference to the brains of the insane. This frequency of hæmorrhages is unquestionably largely influenced by the mode of arterial supply in the parts mentioned, a fact to which Duret, Heubner and others have called our attention. The arteries or the arterioles, which enter these masses, originate directly from the main trunks at the base of the brain. They are smaller in number, but larger in diameter than those which penetrate the grey cortex of the convolutions. They are terminal arteries in the strictest sense of the word, as they break up entirely into capillaries, which are, likewise, of considerably larger transverse diameter than those in the peripheral ganglia. This mode of arterial supply isolates the central masses almost entirely from the cerebral periphery. The area of circulation is, therefore, here much

less extended, the pressure of the blood higher, and, aside from the greater capacity of the capillaries, there exists no other provision to counterbalance deviations from the normal supply of blood which result from an increase or decrease in the action of the heart. These conditions are evidently favorable to arterial ruptures. On the other hand, however, it should not be forgotten that the vigorous development of the capillary system must facilitate absorption. It also affords less danger of the setting in of inflammatory changes by the diapedesis of the white corpuscles of the blood, a condition which has been exceedingly rarely observed in these parts of the encephelon.

The vascular arrangements in the cerebellum are much like those in the cerebral hemispheres. The connective tissue envelop is absent in the cerebellar convolutions, and the border layer of fibrous tissue is developed in a smaller degree. We distinguish three layers, viz.: the grey, the round cell, and the white layer. The ground substance of the grey layer, with its comparatively small number of nuclei, is of the same nature as that of the cerebral convolutions. It receives its prominent feature from the large number of the great ganglion cells at the border of the round cell layer, which send their ramifications, like the roots of a tree, through the whole thickness of the grey layer. They run out into branchlets so delicate that they can not be distinguished from the fine granular matrix in which they are imbedded. Anastomoses between the processes interse, or between the processes of different cells, have never been observed by myself. One process, given off in the direction toward the round cell layer, penetrates this layer, and terminates in a nerve fiber in the white layer. There are two classes of arteries which penetrate the cerebellar convolutions.

The one, the smaller in size and the larger in number, arise from the second arterial network of the pia mater. They are, in fact, nutrient arteries, which run out into the finest capillary network in the grey layer. The second class consists of larger stems, which originate in the first network of the pia mater. They do not commonly send off any branches before they have reached the round cell layer, in which the branches break up into a capillary network almost as dense as that of the grey layer. The main trunk then enters the white layer, following the course of the fibers, gradually dividing and passing over into capillaries. Hæmorrhages in the cerebellum are not so very rare; they occur mostly in the white substance. The ganglionic layer, as it will be seen from our description, is as well protected against extensive or permanent derangements of the vascular system as the grey cortex of the cerebrum.

The vascularization of the pons Varolii, of the medulla oblongata, and of the spinal cord, is in accord with the distribution of grey and white matter in the same. The grey centers and tracts are exceedingly rich in capillaries. The pons receives its supply from the branches of the basilar artery, which likewise form two arterial networks in the pia mater; the upper part of the medulla oblongata from branches of the two vertebral arteries, and the lower part from the spinal arteries. The larger stems, which penetrate these organs, are located in the raphé, and accompany the roots of the nerves.

The part of the central nervous system which is undoubtedly the best protected against sudden and serious alterations in the blood supply, is the spinal cord. The two main arteries, the anterior and the posterior *arteria spinalis*, are of comparatively small

size. They originate from two branchlets given off at an obtuse angle from the two vertebral arteries, and are of about the same transverse diameter down to the *filum terminale*, where they diminish in size. The anterior spinal artery sends off branches at irregular intervals to the right and left. The posterior sends off, at regular intervals, branches of smaller diameter, which follow the posterior nerve roots. Both sets of branches communicate with the intercostal arteries. At the *conus terminalis* both spinal arteries are connected by anastomoses. In their course downwards they also form a separate network of anastomoses in the pia mater, from which the finest nutrient arteries enter the cord at a right angle. Others, of larger diameter, originating directly from the spinal artery and its branches, penetrate the substance of the cord following the tracts of the nerve roots.

It is evident that by these arrangements the greatest uniformity possible in the distribution of nutrient fluid is accomplished. On the one hand, there is an ample supply, since the main source—the vertebral arteries—considerably surpass the spinal arteries in diameter. On the other hand, the latter two are in their entire length almost of the same caliber, equally dividing their contents over the whole organ, while their final communication greatly adds to the uniformity of the blood pressure in all parts of the system. But, furthermore, the connections of this system with the intercostal arteries must serve as a regulator both ways, in an increase as well as in a decrease of pressure, and a compensation is effected before any changes in the nutrient system can possibly become noticeable. This holds good as well where there is a general hyperæmia as in cases of anæmia, so far as the quantity of the blood is concerned.

From the foregoing sketch of the vascular arrangements in the central nervous system, we draw the following general conclusions in regard to the plan of organization, as well as in regard to its effect. In the animal system—that is, in those parts of the nervous centers which are absolutely necessary for the functions of organic life—there exist ample provisions for the preservation of normal conditions; while those parts in which we locate the mechanism which is concerned in the manifestations of psychical phenomena are distinguished by arrangements which facilitate a return to the normal state when this has been disturbed. In a few words, therefore, the resisting power, in regard to affections arising in the vascular system, predominates in the former, and the power of reparation distinguishes the latter. It would be easy enough to furnish ample proofs of the correctness of this view. For the present we shall confine ourselves to those conditions of the vascular system of the nervous centers, which stand in relation to the phenomena comprised under the term “insanity.” And as these phenomena, from their primary stages, are invariably connected with affections of the grey cortex of the cerebrum, it would appear to be our main task first to consider the relation of these to the vascular arrangements. It is beyond discussion that, in all cases of mental disturbance, the vascular system is affected. These affections, however, may be of a secondary as well as of a primary nature. From this fact, therefore, we will have to make two sub-divisions, in the description of the changes which have been observed, namely: those which originate in the nervous centers themselves, arising through and in connection with the special mode and plan of organization which there exists; and those which are produced secondarily, developed from gen-

eral affections of the vascular system of the whole organism.

In regard to the normal, as well as to pathological conditions of the vascular system, we have to take into consideration three factors, viz.: a mechanical factor, dependent upon the physical properties of the vascular system; a physiological factor, dependent on the intervention of the nervous system; and a chemical factor, dependent upon the chemical composition of the blood. We have, first, the simple fact of the movement of a fluid in a system of elastic tubes, forced into them by the heart, a pump in constant action. This is a physical or a mechanical problem, and the phenomenon in itself is subjected to the same physical laws, or hydraulic principles, as are elsewhere valid in nature. But the effect, here, is modified, on the one hand, by energies acting upon the elastic tubes, which constantly alter their physical condition; on the other hand, by the peculiar, constantly changing constitution of the fluid which moves in the tubes. Supposing, therefore, the greatest possible constancy and uniformity of the propulsive power, the velocity of the current, as well as the pressure of the fluid in the system of tubes, will, at all times, be dependent upon the interaction of the three factors mentioned. But of these, apparently only two, the physiological and the chemical, are of variable magnitude.

The physiological factor, the influence of the nervous system, is directed to changes in the caliber of the vessels, and has become an object of wide discussion since the discovery of the so-called vaso-motor system of nerves, or, more correctly, of the existence of vaso-motor fibers, contained in the sympathetic, as well as in the cerebro-spinal nerves.

From a large number of physiological experiments it has been ascertained that the cervical sympathetic

especially, is the seat of vaso-motor fibers for the neck, the head, and, very probably, for the whole cerebro-spinal system. All vaso-motor fibers, as far as it is known at present, have, in common, one general center in the medulla oblongata, located above the upper decussation of the fibers of the anterior pyramids, in the antero-lateral section. It is represented, in its longitudinal extension, by a large, double wedge-shaped, and in transverse sections, elliptical, grey nucleus situated on both sides of the medulla, formerly known as Clarke's antero-lateral nucleus. Besides this, there is a series of sub-centers in the spinal cord.

The important office of this system of nerves is, in the way of reflex action, to maintain and to regulate the normal tone of the vessels by producing dilatation or constriction in the arterial system, and thus effecting changes in the general or local blood-pressure, and determining, according to the general and local conditions, an increase or a decrease in the flow of blood in the one or in the other direction. But a close analysis of the phenomena which follow a section or a stimulation of these nerves—the fundamental experiment by which, in the first case, a dilatation, in the second, a constriction of the corresponding arteries is produced—has shown that this simple conception does not hold for the explanation of all the facts which are observed, for the dilatation, which speedily follows the division of the nerves, disappears in the course of time, without the intervention of any other agent, and the vessels return to their normal caliber. And, further by local application, dilatation, as well as constriction, may be produced. This fact, of course, evidences that it is not solely the influence of the so-called vaso-motor system and its centers, upon which the tonicity of the vascular system depends, but that there exist

peripheral arrangements, conditions in the walls of the vessels themselves, which are capable of producing a similar effect, and by which the influence of the centers in the cerebro-spinal axis and in the sympathetic is modified.

The acknowledgment of these facts is but another proof of the functional reciprocity between the different constituents of the organism, their independence on the one hand, their dependence on the other. Under the normal state of equilibrium they generally do not come into view, but appear to be of the greatest importance in all pathological affections where this equilibrium is disturbed.

When we compare with each other the sensitiveness to the nervous influence, of the three components of the vascular system, we observe that the controlling power of the central nervous mechanism prevails in the arterial system, while the venous and the capillary system respond in a higher degree to local influences. This interesting fact, again, modifies the vaso-motor phenomena in the normal state of things, and far more, as we will see further on, in pathologically altered conditions.

As the second variable factor, which continuously acts upon the vascular system, we have announced, in the foregoing, the constitution and the chemical composition of the blood itself. This depends, for the most part, upon the interaction of this fluid with the different tissues of the organism, and upon their vital condition. Thus, we see the constant normal change in the constitution of the blood, from its arterial to its venous character, and *vice versa*, influence the velocity of the current as well as the pressure in the system. The amount of oxygen, or of carbonic acid, present in the blood, appears to be a most powerful stimulant for the nervous mechanism of the circulatory apparatus. An

increasingly venous character of the blood augments the action of the general vaso-motor center, and increases the blood pressure in the system, while the arterial character prominently affects the peripheral vaso-motor mechanism, by acting directly upon the walls of the vessels, and modifying the changes in the capillary and in the venous districts. Similar changes are undoubtedly produced by various substances accidentally introduced into the blood, or arising in the blood from natural or morbid processes. The chemical compounds originating, in the general and special change of matter, from the dissociation of the tissues and the amount of their elimination, by the function of the special excreting organs of the body, comes here into consideration. The differences in the relative amount of the albuminous compounds and of the saline constituents of the blood affect its flow; and, furthermore, the proportion between its organized elements and the plasm. The important influence of the nature of the organized elements, and the relative quantity in which they are present, upon the alterations in the current of the blood, is a matter directly accessible to observation, although it must be admitted that we know still very little of the character of the material changes which they produce in the anatomical constitution of the vascular ducts themselves.

Upon all the phenomena hitherto mentioned, we look from a physiological point of view. Changes and deviations from the normal, and their return, within certain limits, occur, and it is a general law of the teleological mechanism in organic nature, that the cause of changes or want, in the living organism, is, at the same time, the cause and incitement to satisfy the want; a self-regulating law in nature. But it can not be denied that the physiological conditions often fluct-

uate so near the border of pathological affections that they gradually pass over into them. They can, as such, however, only be recognized where they produce permanent changes in the structural constituents of the parts affected, palpable lesions, which require for their return to the normal state, the intervention of other agents, beyond the physiological remedial power of the organism, and either submit to the action of these, or terminate in a destruction of the histological elements involved.

There is no part of the organism which is more frequently subjected to changes, than the circulatory apparatus and of its components, the capillary system, in the highest degree. This system represents the channels for the distribution and the absorption of material, and is the means of communication between the external conditions of life and the life of the tissues in the higher organized beings. Thus it participates in all processes connected with the life actions of the different tissue elements, as well as with the specific functions of the organs, while its own function necessarily appears to be far more of a passive than of an active character. This is the more evident since the important question, whether the consumption of oxygen and the production of carbonic acid takes place in the vascular ducts by the action of oxidizable material, or in the tissues themselves, has been decided in favor of the latter view.

Nevertheless it must be admitted, that the endothelium, which builds up the capillary sheath, represents more than a simple membrane, and that in itself, it possesses properties which play a certain role in the interchange between the nutritive and the irritative constituents of the blood, and the products of the chemical processes by which the life action of the tissues is maintained. Aside, therefore, from the gen-

eral influence of the propulsive power of the heart, the condition of the capillaries is directly dependent upon: first, the pressure of the blood against their walls, originating from the constrictions and dilatations of the smaller arteries which empty into the capillary system; secondly, upon the peculiar properties of their endothelium; and, thirdly, upon the vital energy of the tissues themselves; and we may add, upon the physical character of the tissues in which they are found.

It has already been remarked in a preceding article, that, according to simple hydraulic principles, the velocity of the blood-current in the capillary system, in general, must be exceedingly slow, aside from the increase of the peripheral resistance, caused by friction, and the normal tonus of the vessels. In the capillaries of the grey cortex of the human brain, for instance, it must be about a thousand times slower than in the aorta, at its point of origin. It can not exceed the one-fiftieth part of an inch, per second, and is probably considerably slower.

Now, we must keep in mind that the arterial system, in the normal state, is at all times overfull, and that it empties its surplus, continuously, into the capillaries. The more extended and delicate the capillaries, the greater the peripheral resistance and the higher the pressure will be in the arterial system, while in the corresponding venous system the pressure is lower, and the veins less full. When, on the other hand, the resistance in the capillary system is diminished, as in a condition of general dilatation of the capillaries, there will be a rise of pressure in the veins, and a gradual fall of pressure in the arteries. Both are physiological conditions, and they may be transient and readily compensated for by a temporary increase or decrease in the action of the heart, as

well as by the action of the peripheral or the central vaso-motor apparatus in the way above indicated. By some or other influence, however, these physiological conditions may become permanent, and pass over into true pathological states, either confined to a certain organ, or affecting the whole vascular system. In the first case they will necessarily lead to alterations in the capillary system, and secondarily, to changes in the nutrition and in the function of the organ affected; in the latter case to alterations in the muscular, or in the valvular mechanism of the heart.

It can be anatomically proved that such affections, referred to in the foregoing, which stand at the border of physiological and pathological conditions, and which lead to alteration in the capillary system, frequently occur, without having at the time of their occurrence visibly interfered with the nutrition, or the function of the organ thus affected. This, for instance, is especially the case in the brain, where, on the one hand, prominently in the grey cortex, conditions exist which are most favorable for the development of locally confined affections, and where, on the other hand, as it seems, no ample provisions exist for the removal of the traces of the alterations which have taken place. I, at least, have not yet dissected one adult brain, either from persons who died accidentally in apparent health, or from persons who had suffered from brain disease previous to death, which did not contain, in the one or in the other convolution, more or less marked evidences of gross alterations in the capillary system. These were represented by the presence of remnants of capillary vessels, which, at one time or other, by causes unknown, must have been cut off from the general circulation. They are found preserved, embedded in the cerebral tissue, forming rigid shrubs, of larger diameter

than the living normal capillary, with thickened, longitudinally striated walls. At the one end they show commonly a kind of a knobby dilatation, which, at one point, runs out into a long filament, probably the collapsed sheath of the unaltered portion of a capillary vessel. Frequently, but not always, they exhibit a slightly glassy appearance, and offer a great resisting power to the influence of acids and alkalies, as well as to ether, chloroform and alcohol. They are of a cartilaginous consistence, and I have never observed any alteration of tissue in their immediate surroundings. Aside from a little granular material, occasionally met with in the tubes, they seem to be filled with a uniform, slightly refracting substance, and the only theory in regard to their origin, which I can suggest, is that they are, as indicated in the foregoing, the remnants of occluded, dilated, and finally degenerated capillary vessels, which have become infiltrated with an inorganic compound, in combination with an albuminoid, which is indifferent to the chemical processes occurring in those parts of the living organism.

It remains to state that the principal seat of this alteration of the capillaries is the grey cortex of the cerebrum; next to this they are occasionally met with in the central grey ganglia, and in the pia mater. In the white layer, in the pons Varolii, the medulla oblongata and the spinal cord they must be exceedingly rare, if they ever occur. By this, of course, I do not mean the occlusion of capillaries *per se*, but the peculiar processes which follow the occlusion, and which lead to the formations above described. In over three hundred examinations of the portions of the brain mentioned, and in twenty-one of the cord, I have never met with a single case.

This is the first material and permanent change in the vascular system of the nervous centers, to which I call attention. Although, in its origin standing at the border of physiological and pathological conditions, it presents in its results, a lesion of true pathological character. In proportion to the extent in which the lesion is found in any given case, it should be taken into consideration, as it is, at all times, an evidence of disturbance in the capillary circulation, which is of significance in an etiological point of view.

[TO BE CONTINUED.]

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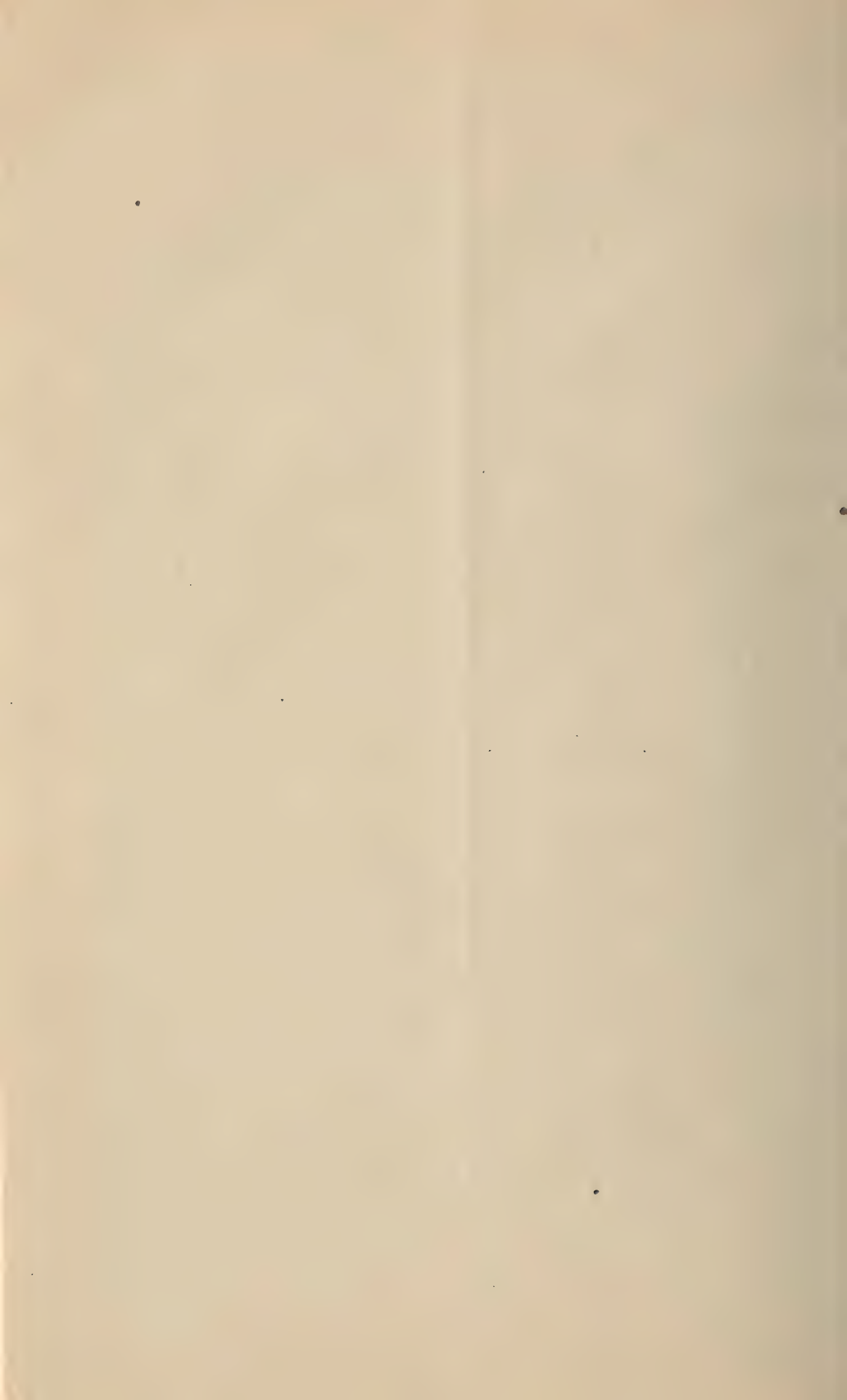
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The Structure of the Vessels of the
Nervous Centers in Health, and
their Changes in Disease.

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PART V.
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By THEODORE DEECKE,
Special Pathologist, New York State Lunatic Asylum, Utica.

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From the *American Journal of Insanity* for April, 1880.



THE STRUCTURE OF THE VESSELS OF THE NERVOUS CENTERS IN HEALTH, AND THEIR CHANGES IN DISEASE.

BY THEODORE DEECKE.

V.

Before I proceed to the special description of the changes in the capillary system of the nervous centers, which I have observed in the brains of persons who have died insane, I wish to discuss a few general questions of importance. When I speak of the brain of a person who has died insane, I certainly consider insanity as an evidence of a chronic and diffuse organic disease of the brain. From a pathological point of view, however, I believe it not justifiable to exclude from consideration such cases of acute and localized affections of the cerebrum and its meninges, as meningitis, insolation, cerebritis, septicæmic infection, which are so frequently combined with symptoms of mental disturbances, and by whose action conditions may develop that must be regarded, not uncommonly, as the very predisposing causes of insanity. Etiologically and physiologically the knowledge of these morbid processes is of the greatest importance for the right understanding of the conditions which have led to a prolonged disorder of the organ.

The theory has been advanced by various authors, that insanity in its early stages is a mere functional disease, that disturbances of the encephalic circulation, that hyperæmia of the brain on the one side, or anæmia on the other, were sufficient causes to interfere directly with the normal functions of the organ, without

having produced any material or structural changes. Even in our days attention is called, over and over again, to the similitude between the condition of the brain in insanity and the arrest or the conversion of its function during sleep; or its excitement and perversion of function, as, for example, in acute alcoholic intoxication. But all these theories have accomplished little for a better understanding of the subject.

The theory that any alteration in the function of an organ, or of its constituents, could occur without being concomitant with structural changes, is directly in opposition to acknowledged physiological principles. In every living being every histological element is subjected to a continual change of its constituents, and the nature of the function of any organ, or of its constituents, depends upon the nature of the changes which take place. This has never been doubted, and it holds true for pathological, as well as for the normal physiological processes of life. An organic entity in the state of life represents a perfect oneness, an insoluble unity of form, composition and function. Therefore one form is not equal to another, and the one is not equal to itself from one moment to the other, although both are similar, and we are not able even in thought to separate the function from the substance which performs the function, or the substance from the form under which it appears.

Alteration, therefore, in the blood supply of an organ, the state of fullness or emptiness of its vascular apparatus must evidently be accompanied by structural changes; first, at least, in the histological elements of the blood ducts themselves. The quality and the quantity of blood, then, must affect, secondarily, the affinity of all the structural elements of the organ to the nutrient fluid, as soon as this comes into contact with them, and the result of this changing affinity will

necessarily be an alteration of the elements in composition, form and function. Whether these continuous alterations fluctuate inside the limits of normal physiological processes or not, can only be dependent upon the degree and the nature of the changes in the affinity which have occurred.

In a preceding article in the January number of this JOURNAL, I called attention to the fact that even inside the limits of physiological conditions, in the capillary circulation in the nervous centers, changes take place, of which permanent material traces can be observed. I mentioned this fact for the reason that the peculiar degeneration, referred to, has been described by various authors, as Lubimoff, Arndt, Schüle, Adler, Neelson and others, as evidences of a pathological affection of the brain, an opinion with which I can not fully agree. I consider them as pathological only when they are found in large numbers, and when other lesions of the nervous tissue are demonstrable, from the presence of which, the conclusion can be drawn that the organ has suffered from disorders in its nutrition.

The reason why the condition of the brain in its state of converted activity during sleep is so frequently placed in similitude with the state of the brain in insanity, is, that there is an apparent impairment and irregularity of mental functions, physiologically, perhaps, explainable; and the same may be said, in a measure, in regard to the comparison of insanity with the phenomena of intoxication. This similitude they seem to cite to be the more striking, as in the one case, during sleep, they claimed that the inactivity of the organ was due to a state of marked anæmia, a condition frequently connected with insanity; while in alcoholic intoxication the organ has been said to be in a high state of congestion, and at the same time under the in-

fluence of a poisonous substance introduced into the blood. Both of these theories, however, rest upon a mere hypothetical foundation, and not upon facts.

As to the theory of the anæmic condition of the brain during sleep, it must be said that this has not been proved neither by the reasons brought forward by Blumenbach, nor by the experiments of Fleming concerning the effect of compressing the carotid arteries on the functions of the brain, nor by those made by Arthur Durham, Hammond and others. Even the result of Hughling Jackson's ophthalmoscopic observations during sleep do not permit of any conclusions concerning the capillary circulation in the mass of the cerebrum itself.

In the case related by Blumenbach, where after recovery from a fracture of the frontal bone near the coronal suture, a hiatus remained, which was only covered by the integument, the changes between the convex and the concave appearance of the chasm, the former when the person was awake, the latter when he was sleeping, were apparently due to alterations in the movements of the cerebro-spinal fluid. Whether the brain itself at the one or the other time was in a collapsed condition of course does not follow. When, however, Hammond states, in support of Blumenbach's view of the collapse of the brain during sleep, that in infants the portion of the scalp covering the anterior fontanelle is always depressed during sleep and elevated during wakefulness, I must say that this is the reverse of what I have observed, and that this statement is not in accordance with the figures of the sphygmographic tracings which I have repeatedly taken at the point in question from children in perfect health.

The temporary unconsciousness and insensibility produced by compressing the carotid arteries, as observed

by Fleming, has apparently nothing to do with physiological sleep; no more than the latter has with the unconsciousness during or after an epileptic fit or during fainting. And the results from the experiments of Durham and Hammond, aside from the abnormal conditions connected with the gross surgical injury, the venous congestion produced by the use of chloroform, or from the conditions brought about by the administration of opium, are at least very problematical. For, it can not be seen how far the simple ocular inspection of a small portion of the exposed pia mater justifies the drawing of conclusions concerning the condition of the substance of the brain itself, especially since we have gained a more complete knowledge of its complicated vascular arrangements.

Moreover, this *humoral* physiology does not suffice to explain the phenomenon of sleep. It does not give us the slightest idea of the condition of the histological elements of that prominent part of the nervous centers which is subjected to those periodical times of rest and apparent inactivity. That its constituent elements can not be inactive, in the proper sense of the word, is not doubted by anybody, since, after the apparent rest, they are fit again to eliminate living forces with renewed energy. We must suppose, therefore, that during sleep processes are going on, different, not only in degree, from those connected with the visible manifestations of life, but different in their essential nature. Now, if it should be possible here, perhaps only to pave the way for a closer insight into the nature of these processes, I believe this will also throw at least some light upon those which, according to anatomical facts, observed, we must suppose, have led to the establishment of the abnormal conditions of life and life actions. In a former one of this series of articles, I have already

touched upon some points which come here into consideration, but the importance of the question may excuse a few necessary repetitions.

The theory of the existence of an anæmic state of the brain during sleep, seems to be, to begin with, not supported by the mechanical phenomena connected with its occurrence, nor by our daily experience. During sleep, we are in the habit of placing the body in a horizontal position. When the head rests in the same horizontal line with the longitudinal axis of the body, or sinks below that line, a very unpleasant feeling of drowsiness will precede the sleep; the sleep will be deeper than usual, and the person will be aroused with difficulty; he will not feel refreshed after the rest, and pain or dullness in the head will follow. This has always been experienced, and has developed the habit of giving the head during sleep, a slightly elevated position—some six or eight inches above the longitudinal axis of the body. But what is the cause of those phenomena? According to the law of gravitation, the horizontal position of the body must evidently facilitate the flow of the blood to the head. In the position of the latter, however, below the horizontal axis of the whole body, an unusual and abnormal accumulation of the blood must result; and I think it is quite rational to ascribe to this circumstance, the phenomena above referred to. This is the simplest explanation, yet its correctness has been proved, without any vivisection, by the fact that the same mechanical principle which was the cause of the phenomena observed, was the cause of preventing their development; the slightly elevated position of the head above the line of the horizontal axis of the body, removes, at once, all the difficulties.

Now, in view of this universal experience, I do not see how the theory of an anæmic condition of the brain in the production of sleep, can possibly be sustained. The fact that sleep may occasionally occur in all positions the body may assume, can not be brought forward as an argument in favor of the theory, and I certainly do not suppose that the horizontal position of the body during sleep, by itself, has anything to do with the production of sleep; but the choice of position has, nevertheless, a physiological foundation. The horizontal position of the body apparently favors a more equal distribution of the blood through it, and relieves the heart, temporarily, of a part of its work. The current of the blood becomes slower, the respirations are diminished and more regular. This, however, does not show that any organ, during that time, should be deprived of its normal quantity of nutrient fluid.

It is my opinion that the theory of the anæmic condition of the brain during sleep has its foundation in the comparison with the periodical fluctuations in the blood supply of other organs of the body during their states of excited or diminished activity. But this is entirely wrong. The nervous tissue is not to be compared with the secreting tissue of a gland; it is not an erectile tissue, and the chemical processes by which it accumulates its power and by which it eliminates its energy, are widely different from those which take place in the other tissues of the different organs of the body. The causes, therefore, of the periodical states of rest and activity of the brain, must be sought in other conditions than the supposed variations in the supply of nutrient material to the organ. If there is any similitude between the sleeping brain and its perverted function in insanity—and a certain resemblance can not be denied—it will become necessary to look for the meaning of it from another point of view.

As to the condition of the brain in alcoholic intoxication, and the resemblance between the symptoms connected with it and the symptoms observed in certain forms of insanity, it must not be forgotten, that in the former case, we have to do with the action of a palpal substance introduced into the blood, the alcohol, upon the tissues of the body and their change of matter. It is true, the full history of alcohol in the animal system can not yet be given, but we know that only a limited quantity during a certain time participates in the organic change of matter, while a surplus, if present, passes, undecomposed, through the system, and is re-excreted by the way of the lungs, the skin, the kidneys and the intestinal canal, on its way variously interfering with the proper nutrition of the tissues. That part of the alcohol which enters into the change of matter, acts as a stimulant, and the quantity which may be consumed in this way is variable, dependent upon individual circumstances, and upon the degree of dilution in which it is introduced. By its action, the general tonus in the arterial system is increased, and an acceleration of the blood current ensues. Its principal action is upon the nervous centers, especially the grey substance of the brain; its functional activity is augmented, while at the same time a general feeling of pleasure and satisfaction is experienced. All this is *stimulation* of function, a process entirely inside the limits of physiological life actions. It can not, in this degree, be considered as injurious to health, especially not to the health of an organ like the brain, which is during almost all of life in a state of growth and development. On the contrary, the *stimulation* develops its strength, and lays open more readily its energies.

From this condition, of course, *intoxication* presents quite a different feature. It is a state due to the presence of a surplus of alcoholic substances in the body, which can not be taken up in the system. This surplus interferes with the digestion,* it interferes with the general circulation in the body; in the one part producing a venous stasis and dilatation of the veins, in the other, an atonic condition of the arteries, combined with a state of anæmia in the capillary system. The phenomena of intoxication are not, in fact, combined, as commonly accepted, with an active congestion, but with the capillary anæmia which follows the congestion, and with its consequences, viz: the deprival of the tissue of nutrient material, and the changes which are thereby induced. We add to it, that this takes place under the direct influence of a substance which can not be assimilated or readily disposed of, although it penetrates all tissues of the body, and which, therefore, under such conditions, acts like a poison. Aside from this, we must further conclude from chemical experiences that the admixture of alcohol to the blood greatly alters its affinity to the gaseous substances carried to and eliminated from the tissues, and its capacity of keeping them in solution.

Now in regard to the series of symptoms connected with alcoholic intoxication, and to those presented in insanity, the existence of some resemblance must be admitted. We will see later on, in how far there

* The results of experiments quite recently laid before the "Société de Biologie," in Paris, showed, that in a mixture of 200 grammes of meat and 75 grammes of eau de vie introduced into the stomach of a dog, not a trace of digestion, even after six hours, had commenced. The stomach contained, after that time, the 200 grammes of meat, perfectly intact, and 160 grammes of a slightly acid liquid, which proved to be entirely incapable of producing artificial digestion. In mixtures of 200 grammes of meat and 25 grammes of eau de vie or 150 grammes of wine, the digestion was found to be accelerated.

—*Progrès Médical*, February 21, 1880.

is also a correspondence between the causes of the affection of the organ, in producing the conditions which accompany the phenomena observed.

I return to the phenomenon of physiological sleep, and to a closer discussion of the process connected with it.

We have seen in the foregoing, that the theory of an anæmic condition of the brain during sleep can not be sustained; the less, as it is not disputed, that the elements of the organ during that time must be most active, at least in one direction, in accumulating power; a large amount of the power, which is destined to be eliminated during the state of being awake. Sleep is the time, to use an image, when the spring of the clock-work is wound up. But what is it, in the living cell, that corresponds to the spring in the clock, and of what kind are the processes which are similar to the winding up of the clock? At first sight it may seem as if the spring corresponded to stored up substance, and the winding up, to the process of storing up material. This may be so, but not in a general sense, since this process takes place continuously during the state of wakening, as well as during sleep. Moreover, the *general* change of matter in a state of health, at least so far as the nitrogenous compounds are concerned, must be considered quantitatively the same during both periods, as I have shown in another article, published in this JOURNAL.* This, therefore, can not be the winding up of the clock.

The key to a right conception of this secret of nature was discovered by Liebig.† This great chemist and physiologist, starting from the observation, that in

* July, 1879. Urea and phosphoric acid in the urine in anæmia.

† Justus v. Liebig: On Fermentation, on the source of muscular power, and on nutrition: *Academie-Berichte, München*, 1869, II, 4.

the processes of organic life the products of the decomposition of the albuminous compounds, by the action of oxygen, exhibited not the slightest similarity to those artificially produced in the laboratories of the chemists, while this was not so with the products of oxydation of the hydro-carbonic radicals, concluded that the process of the formation of carbonic acid by the organic cell was not one of common oxydation. It could not be a decomposition produced by the action of free oxygen upon the carbonic molecules. He propounded, therefore, the theory, that the process was one of dissociation by the action of, chemically already assimilated, that is, intramolecular oxygen. The great consequences and the importance of this ingenious theory for the chemistry of life has but recently been acknowledged, and especially through the efforts of E. Pflüger, in Bonn,* we have gained an insight into those secret workings of nature beyond expectation.

The only apparent difficulty brought forward as an argument against this theory, is the supposition of the spontaneity of the dissociations which it is said to involve. But this has weight only, when we consider a chemical molecule as a system of atoms in a state of static equilibrium. This idea, however, is inconsistent with the phenomena of the specific heat of the bodies, as well as with the principles of the mechanical theory of heat and their consequences. From these, we must conclude that a chemical molecule even in the solid state of aggregation, is a system of atoms in motion against each other, or of oscillating molecules of different orders, subjected to the changing influences of inherent and transmitted forces or motions. As now, a

* Ueber die physiologische Verbrennung in den lebendigen Organismen Pflüger. Archiv: Vol. X, 6 and 7, *vide* this JOURNAL, October, 1875. Retrospect of German Literature.

dynamic equilibrium, *de facto*, does not exist in any system in nature, but only arrangements which are more or less remote from, or approach a state of equilibrium, it is evident that the process of the dissociation of a system is but a special case of the general conversions of motions, which everywhere and continuously take place in nature. Clausius, in his researches into the mechanical theory of heat, has mathematically shown that the larger the number of atoms or of molecules of different orders, of which a given system consists, that the more differentiated is its intramolecular motion, the greater the difference between this and the *vis viva* of the molecule, the more remote the system from a state of dynamic equilibrium, and the more liable to dissociate. But the process of dissociation is not a function of the molecular constitution of the system, and not separated from the process of growth of the molecule by a predefined line of demarcation.

The nature of the former process is, that in the polymerous constitution of the growing molecule, a metamerism is produced; that is, an interchanging of the atoms. Under the formation of carbonic acid, the part of the chemical, potential energy, consumed by this process is converted into heat, that is, increased motion of the newly formed carbonic acid molecule. In the violent oscillations of each of these seceding molecules, there is a certain amount of force eliminated, transferable to neighboring systems.

The processes of dissociation, therefore, impulsive in their nature, appear to be themselves the result of impulses; of impulses of external origin, the energy of which, to a certain extent, must determine the nature and the products of the dissociation. Just as the nature of the curve of a celestial body in motion—whether it describes an ellipse, a parabola or a hyperbola—is not dependent upon the direction, but upon the energy of

the first impulse, or the primary velocity of the body, and upon its distance from the center of gravitation—a simile in which the distance from the center of gravitation is equal to the constitution of the molecule, the magnitude of the impulse to the act of dissociation, and the curve equal to its effect.

In the light of these considerations, we may conceive, without difficulty, the growing of a living molecule as a process, not in itself limited; and also that the entrance of each new atom into the molecule increases its intramolecular motion or energy; we may also conceive the dissociation of the molecules as a process neither predefined in its beginning nor in its termination, but dependent, though not exclusively, upon the nature of the inciting impulse.

Thus we see that the organism possesses, in the property of the organic molecule, to grow and to increase its intramolecular motion or energy, an arrangement which, like the spring of the clock, permits of an accumulation of force; the spring of the clock is the intramolecular motion or tension, the winding up of the spring the growth of the molecule, or the accumulation of intramolecular force, which is materially represented by the amount of intramolecular oxygen; while by the processes of dissociation with the seceding carbonic acid molecules, living forces are eliminated, by which a certain amount of work, as in the clock, is performed without necessitating an immediate restitution, at the place where they are eliminated. But as soon as the spring has run down, the clock-work stops; and as soon as the intramolecular motion has lost a certain amount of its intensity, the formation of carbonic acid ceases, and with this the external manifestations of life of the molecule. Yet this cessation is not the death of the molecule; the clock-work only stopped, while death would be the destruction of the clock.

It is evident that this property of the living molecule is of universal existence, and that each organic element in the state of life, each cell, every tissue of the organism is more or less subjected to similar periodical changes of the chemical processes, connected with their manifestations of life. In the life of no other tissue, however, will this change be experienced with more distinctness than in the nervous tissue; and especially in that part of the nerve tissue, the grey substance of the brain, in which we locate the seat of the mechanism, which is concerned in the manifestations of psychical life-action, here especially, where, apparently, the function is coincident with the consciousness of the function. Yet, it is important to remark, that the functions of which we really become conscious are those which are in connection with our relations to the external world. It is hereby shown, on the one side, that consciousness is the experience of the sum of our existence in opposition to the external world; and, on the other, that we have no experience of that part of the function of the grey substance of the brain, which relates to its own life and existence.

We have seen, in the foregoing, that from the two series of processes, connected with organic life, the growth of the living molecule and its dissociations, the nature of the latter were dependent upon the intensity or the nature of the inciting impulse. The fact of the connection of the living molecules of the grey substance of the brain with the external world, by the peripheric expansions, which receive and conduct the impulses from the outward processes to the constituent elements of the organ, is of the utmost importance. This is one of the conditions of the organ. In the state of acting with the consciousness of our relations to the external world, we say we are awake. During sleep we are not

conscious of these relations. It is, therefore, evident that those processes in the living molecules of the brain, which are incited by the action of external impulses, that is, the processes of dissociation, quantitatively and peculiar in quality, must prevail during the state of being awake. During sleep the dissociations must be of a different nature, since the impulses are of different character, and the processes of the growth of the molecule are becoming predominant.

We shut out, therefore, for the purpose of getting asleep, as much as possible, the direct influences of impulses from the external world. We seek for the darkness, for silence, and a comfortable warmth of our surroundings, and select a place where the body can rest in an easy position. And this exclusion from the direct influences of the external world is the first and most important physiological condition for the production of sleep, and not the supposed anæmia of the organ, which is expected to restore during that time its lost energies by an increased assimilation.

The awakening from the normal healthy sleep is a sudden act. The impulses originating from a ray of light, from a sound, from an unusual taste or odor, from an irritation of the skin, or its prolongation, the mucous membrane of the digestive tract, of the bladder, are sufficient to incite dissociations of a nature that are capable of inciting numerous others. A frequent repetition of the impulses will become necessary, in order to keep up the incited condition; otherwise the process stops, and its effect dies away; the organ sinks back into the preceding condition. This takes place when there is still a lack of intramolecular motion or tension. In the other case the slightest impulse may suffice to produce a series of dissociations, until again a low degree of tension in the molecule is reached.

Since now, as we have seen above, the nature and the effect of the dissociations is dependent upon the nature or the intensity of the impulse, it is not excluded that dissociations of some kind continuously take place. We distinguish, as is well known, a third condition of the brain, lying between the state of wakening and sleep—the state of dreaming—which, again, must be connected with certain processes of dissociation, corresponding to the nature of the impulses by which they are incited. And there is no reason why it should not be justifiable to presume the possibility of the occurrence of still other conditions, different from those before mentioned, especially when substances are introduced into the change of matter which, in the one or the other way, are capable of acting impulsively upon the living molecules of the grey substance of the brain. The phenomena of stimulation may possibly be designated as an illustration of a physiological condition of the brain of this order.

The conditions which give rise to symptoms of a pathological character may be explained, to some extent at least, by the principles already enunciated in this article. In the first instance, the degree of the nutrition of the tissues comes into consideration. In regard to the changes in the conditions of an organ, inside the limits of physiological life, we have seen that the participation of the circulatory apparatus in the changes is not of primary, but of secondary importance. This is not so in pathological affections, which always arise in and are primarily combined with alterations in the vascular system; a fact that shows, on the one side, the remarkable difference between the two conditions, and, on the other, explains in what way the latter conditions may be developed out of the former.

If we compare, therefore, the condition of the brain of persons who have died insane with that of a normal brain, for example, of a person who died by an accident in full state of health, there will be the remarkable difference observed, that the organ of every person who died under symptoms of insanity exhibits more or less, according to the duration of the affection, an atrophic character, combined with evidences of disturbances in the capillary circulatory system. The origin of these must be looked for in the existence of a prolonged capillary anæmia, as the consequences of pathological alterations in the structure of the capillary vessels themselves. The fact that we frequently find an extraordinary hyperæmic condition of the organ after death, does not prove that this was the general condition during life, and during the disease. It is only an evidence that conditions must have existed in the organ which rendered it liable to abnormal congestions. We must distinguish between two different conditions, with which a prolonged capillary anæmia is connected. In the one the anæmia is due to a stenosis, a contraction of the capillaries; in the other, to a dilatation of the same. In the latter case, evidently, circumstances existed during life which favored changes between anæmic and hyperæmic states of the organ. From the nature of the affection of the capillaries, we must conclude in such cases that the hyperæmia was not one of prolonged duration, that it must have been followed, in every case, by an abnormal emptiness of the dilated vessels, and that the true condition of the organ during life has been one of anæmia.

Atrophy of the brain, which is here, of course, a general term, and not the expression for *one* distinct anatomical change in the tissues, is the common feature of the organ in insanity. In regard to the states present

in the two primary stages of the affection, characterized by the symptoms of melancholia and of mania, it must be said that in both, in consequence of the prolonged anæmia, the processes of the growth of the molecular elements of the grey substance must have been impaired. In the former, in connection with the capillary stenosis, this is followed by an abnormal accumulation of excreted material, and a decrease and an alteration of the processes of dissociation; in the latter, in connection with the dilatation of the capillaries, there is an increase of discharge, and an increase and alteration of the processes of dissociation. Thus one pathological condition, the capillary anæmia, has two distinctly different causes and two effects, similar, but also different in character. From this it is evident that there exists not the slightest similitude between any of these conditions of the brain and its condition during sleep. And the same must be said in regard to the symptoms presented in physiological sleep and in insanity. In sleep there is an entire lack of consciousness, which is not so in insanity, although it is frequently impaired and perverted.

The condition of the brain of the insane has by others, especially French authors, been compared with the condition during the state of dreaming. Yet here also the same argument, as in the former case, must be sustained against the existence of any similitude, perhaps with the only exception that we must presume, in both, alterations in the processes of dissociation. The supposed resemblance between the symptoms and their causes has likewise no foundation. During the state of dreaming the consciousness is suspended in regard to external relations, while the senses are closed as during sleep. In insanity we find, in a measure, the same thing, while the senses are open, a difference which

shows the existence of conditions and processes entirely different in nature.

It remains, therefore, only to consider the condition of the brain in insanity as one throughout altered by pathological processes. The polymerous constitution of molecules of the grey substance must be altered, the processes of dissociation must be of another nature. It will become the task in the future of a new branch of science, of a molecular pathology, to elucidate the causes and the nature of the processes connected with these phenomena. When we proceed to a comparison of the condition of the brain, in insanity and during alcoholic intoxication, we find at once one striking similitude, that is, the anæmic state of the organ in both cases. Yet in the latter this is concomitant with the presence of a foreign substance, which acts like a poison upon the tissues and their change of matter. The condition with its symptoms, is removed as soon as the substance and its immediate effect is removed. Nevertheless it is an acknowledged fact that during the existence of that condition the phenomena observed closely resemble those observed in certain forms of insanity. The resemblance goes even so far that the two primary forms, according to individual circumstances and dispositions, have their simile in the phenomena produced by alcoholic intoxication. Furthermore the alterations in the capillary circulation of the brain and their consequences, artificially produced by the abuse of alcohol, always lead to permanent material changes of a true pathological character, which either manifest their existence under the group of symptoms known as chronic alcoholism, or which produce conditions, connected with graver functional disturbances, and which must be considered as predisposing the organ to the development of that series of affections which is connected with the phenomena insanity.

(TO BE CONTINUED).

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THE STRUCTURE OF THE VESSELS OF THE
NERVOUS CENTERS IN HEALTH, AND
THEIR CHANGES IN DISEASE.

PART VI.

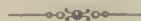
ON SOME CHANGES IN THE GANGLION
CELLS OF THE GREY CORTEX OF THE
BRAIN IN ACUTE DELIRIUM, AND THEIR
RELATION TO THOSE IN ACUTE INSAN-
ITY AND IN DEMENTIA.

PART I.



By **THEODORE DEECKE,**

Special Pathologist, New York State Lunatic Asylum.



[From the *American Journal of Insanity*, for January, 1881.]

THE STRUCTURE OF THE VESSELS OF THE NERVOUS CENTERS IN HEALTH, AND THEIR CHANGES IN DISEASE.

BY THEODORE DEECKE.

VI.

In part four of this article,* attention was called to structural alterations in the capillary system of the grey cortex of the brain, which, although presenting appearances of pathological change, may occur, without being necessarily connected with any noticeable functional disturbances. They were claimed to be the result of processes, which in their nature stand at the very border of physiological and pathological conditions. From the microscopic appearance of this structural change, I propose to call it the *callous* degeneration of the capillaries. It is marked by a peculiar kind of swelling and induration, which the endothelium cells undergo, concomitant with irregular dilatations of the vessel and, at some places, with an occlusion and cutting off of the branchlets thus affected, from the general circulation. As these conditions of capillaries are also found in the brain of persons with no previous history of disease, who died accidentally, in apparently good health, I consider them pathologically of import-

* January, 1880.

ance only in proportion to the extent in which they are found in any given case,* or when with them, other lesions or other evidences of morbid processes in the organ are observed. More recent investigations into this matter induce me to fully sustain this statement.

In the following pages I confine myself to their appearance in the cases last mentioned. From the material before me I select, as illustrations, two remarkable cases, in which the most frequent occurrence of these lesions was concomitant with extensive capillary embolisms. In both cases there were marked febrile cerebral symptoms; an acute delirium with a high degree of maniacal excitement. Temperature fluctuating from 102° to 104° Fahr. Pulse varying between 94 and 120, in an inverse ratio to the rise of the temperature. Lips and mouth dry; tongue dry and cracked. Respiration 20 to 24, at times shallow, with heavy breathing. Pupils small, at times not responding to light. Face and extremities at times purple, cyanosed. Death occurred in coma. In both cases the disease was of short duration, viz.: eleven days in the one, thirteen in the other. The age of the one patient was sixty-five, of the other thirty-five; the one died on the first day, the other on the eighth day after admission.

At the autopsy in the first case, the kidneys were found congested, and the spleen much enlarged. The heart was fatty. Both lungs were congested; the lower lobe of the left lung consolidated, and on section of a peculiar dirty, in some portions, greyish brown color. The left pulmonary vein was almost completely obliterated by a thrombus, one and three-quarters of an inch in length, which had undergone partial decay, and about

*See Article IV, January, 1880.

two tablespoonsful of a white, creamy matter escaped from the vessel after dissection. The thrombus was not of very recent formation; it was laminated, and consisted of concentric red and grey layers, formed by accumulations of red and white blood corpuscles. There was no further organization of its elements, but the greater part of it was solid, and firmly adherent to the inner wall of the vessel. At its termination, the thrombus presented a yellowish grey color, and was of cheesy consistence. The pulpy or creamy matter collected from the vessel was composed of a finely granular debris, which contained an immense number of spherical bodies, formed of micrococci. Sections through the enlarged spleen showed the intra-vascular chords or the lymphoid parenchyma of the pulp, thickly packed with pigment masses. The blood was of neutral reaction. The proportion of white and red blood corpuscles, in an average of ten separate examinations, was as one to three hundred. Here and there white cells were observed of two and two and a half the diameter of an ordinary white blood corpuscle. Hæmoglobine 10.⁴⁵ per cent. Samples of blood taken from the cavities of the heart, the lungs, the liver and the kidneys, showed an admixture of a finely granular detritus, and of globular masses of micrococci, from the size of a small red to that of a large white blood corpuscle.

Microscopic sections through the affected parts of the lung showed a catarrhal bronchitis and a catarrhal pneumonia in the lower lobe of the left lung. The alveoli of the consolidated portions of the lung were, to a large extent, infiltrated with micrococci, in the majority of instances densely packed with these bodies.

When the encephalon was examined, it was noticed that the dura mater was very hyperemic. The longitudinal sinus was very firm to the touch, much dilated

at its central arch, and, like the veins emptying into it, filled with solid blood and fibrin coagula. They did not, however, firmly adhere to the inner wall of the vessels, which appeared to be intact after removing the clots. The inner leaf of the dura mater was here and there slightly ecchymotic, and presented fine, yellowish red punctations. The pia mater, over both hemispheres, showed a high arterial and venous congestion; at the base of the brain, over the medulla oblongata and the pons, it was remarkably pale and anæmic. A closer examination of the supplying arteries at the base, and their contents, revealed the presence of micrococci and a granular detritus-like matter in the carotis interna, in the middle, in the anterior and in the posterior cerebral arteries, and in the anterior and posterior communicans. None of these vessels were, however, occluded. The brain, on section, in almost all its parts, exhibited a tinted appearance of the grey cortex and the puncta vasculosa in the centrum ovale. There was a bloody serum in the lateral ventricles; but nowhere hæmorrhagic foci.

Microscopic sections through the convolutions of the brain showed most extended capillary embolisms, especially marked in the temporal lobes, in the anterior and posterior central and the ascending parietal convolutions, and by far more frequent in the left than in the right half. There was, however, no part of the brain found entirely free from emboli. The substance of the emboli was more generally of a fibrinous than of a fatty nature, yet in the fibrin-coagula of the arterioles and larger and dilated capillaries globules of micrococci, and accumulations of a granular matter were most frequently found; in other instances the embolic masses were densely beset with fine prismatic crystals of hæmatoin. Of the nervous elements the pyramidal cells of

the second layer only of the convolutions, most affected, and some cells of the corpora striata and the optic thalami had undergone a cloudy swelling, and were of glassy appearance, so that the nucleus of these was rarely outlined. Yet, there was, aside from this, another pathological element present, of which I will speak further on. In this case, the affection had apparently originated in the respiratory organs. The history of the case is, in short, the following: The patient was a sailor, single, sixty-six years of age. Had been in a Sailor's Home about twelve years and was always steady and correct in habits. About two weeks and a half before admission, when he was visited by friends, he was allowed to accompany them to a neighboring village, where they gave him liquor and indulged in excesses. He returned intoxicated, and sick from unusual exposure, and was for this offense deprived of certain privileges, from which time he appeared to labor under some mental depression and excitement. Four days later, while in chapel, in the midst of the sermon, he arose and asserted, with great emphasis, "I am God;" repeated this assertion and said that when he was dead the sun would never rise again. After this he continued to be very delirious. Ten days later he was brought to the asylum in restraint, hands tied together with a rope. In office was, at times, very loud and demonstrative; paid no attention to anything said to him; then again sat with head down muttering to himself; then started up suddenly and with eyes fixed on the wall shouted incoherently; was thin in flesh, haggard, and appeared very sick and feeble. Pulse 84. Temperature 102° Fahr. He died twenty-four hours after admission.

Symptomatically, as it will be conceded, this case stood right at the border of a so-called acute delirium

and acute insanity. There was, undoubtedly, a delusion, preceded by a state of mental depression and excitement; yet, this appeared to be entirely covered up by a general confusion of ideas—a symptom so frequently associated with sudden attacks of acute febrile diseases. And, taking into consideration the rapid course of the disease, it seems to be impossible to decide in favor of the one or the other interpretation. Etiologically, two important factors were present—a physical, the excessive use of liquor and the exposure which created a bodily disease; and a psychical, the mental depression and excitement originating in the consciousness of the offense committed, and of the fact of being, therefore, deprived of certain privileges, two things, apparently, of great weight in the life of the individual. Anatomically, there was a severe affection of an organ, essential to physical life. The peculiar pathological nature of the affection was such that its germs spread out rapidly, and were carried into all parts of the circulatory apparatus. The condition of the blood was altered, and the lack of a proper nutrition and a normal change of matter interfered directly with the normal functions of all organs of the body.

The first physiological effect perceptible, was, undoubtedly, a general stasis in the venous system, associated with an arterial engorgement. There was, then, an occlusion of the smaller nutrient vessels by emboli, and, consequently, as the first pathological factor, a back flow of the blood in the districts supplied by terminal arteries, in Cohnheim's sense. This must have been especially of importance in the brain, the organ which here comes before all the others, into consideration, where this system is most prominently developed. Since we know, by direct observations, that in such cases, the checked blood-current empties through the nearest

unaffected artery, into the veins, this must have greatly added to the stasis and the engorgement in the latter, and must have produced dilatations of the veins, morbid conditions which were found so well pronounced at the autopsy.

It will be seen from the foregoing, that in this case, all the circumstances were present, which would favor the development of inflammatory processes in the districts affected, viz: the diapedesis of white, even of red blood corpuscles, or even actual hæmorrhages. Of the latter two, there were, however, no evidences detectable. Concerning the diapedesis of the white corpuscles, it must be admitted that its demonstration in the tissues of the nervous centers, especially in the grey cortex of the convolutions, is connected with peculiar difficulties, since we have no means at disposal, of distinguishing the white corpuscles from lymphoid cells, or from the nuclei of the neuroglia. In the case before us, however, and the observation dates as far back as 1876, I have detected the presence of elements in the tissues affected, which are unquestionably of pathological nature, and seem to be evidences of the existence of diffuse inflammatory processes connected with capillary embolism. This would be quite in conformity with the suggestion, first made by Charlton Bastian, of the possible relation between febrile cerebral symptoms and capillary occlusions. From my own observations during the last four years, I can add four new cases to the one related, which I selected for communication, on account of the clearness of the clinical picture, and of the etiology, the anatomy, and the physiology of the disease. In the second case, mentioned in these pages, and which will be described further on, the anatomical condition was diagnosed, and the correctness of the diagnosis established by the autopsy.

The elements, referred to above, upon the presence of which, anatomically, the theory of the existence of diffuse inflammatory processes, associated with capillary embolisms in the brain is based, are peculiar cells or bodies, found in large number in the tissue of the parts affected, corpuscles of various size, up to the one-five-hundredth of an inch in diameter. They are globular, round, elliptic or oval, smooth bodies, perfectly transparent, yet slightly refracting the light. If the latter was not the case, they could easily be taken for hollow spaces. Inside these bodies, there is, at all times found, enclosed like the nucleus in a cell, a white cell or corpuscle. It is an interesting fact—and in consequence of this only are these bodies detectable in the tissue—that in fresh specimens, viz: sections through the fresh brain, neither the substance of these bodies nor their nucleus, or the white cell in the center, imbibes the color from the carmine solution. They are thus distinguished from the nuclei of the neuroglia, the ganglion cells and the lymphoid cells, which all become more marked by taking up the color. Under all circumstances, however, they are easily overlooked; yet, even in stained sections through the hardened tissue, they can be made out when the attention is directed to them. Since the bodies are, as stated, on the average, of considerable size, the sections, of course, should not be too thin; in which case, they would present the appearance of an empty space.

Now, my theory as to the origin of these bodies in the tissue is, that they are migrated white corpuscles, surrounded by a peculiar gelatinous protoplasmatic substance, and that the whole represents a new formation, as the product of an inflammatory process. The protoplasmatic envelop being of a different nature from the ordinary cell protoplasm, protects the white cell

FIG. 7.



FIG. 6.



FIG. 3.



FIG. 5.



FIG. 4.



FIG. 8.



FIG. 2.

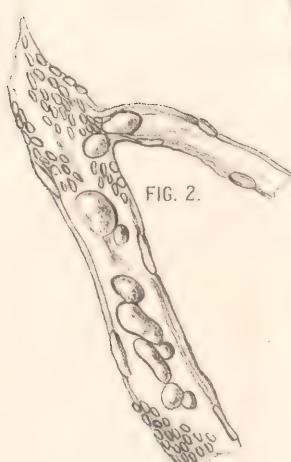


FIG. 1.



FIG. 9.



or the nucleus from becoming colored, when placed in the carmine fluid; it does not resist, however, the action of the iodine solution, which colors the nucleus dark—the protoplasmatic envelop light yellow. In plate I, figs. 8 and 9, I give as good a representation of the bodies in question, as possible; the peculiar slight refracting power of the protoplasm or gelatinous envelop, of course, can not be illustrated.

Another remarkable anatomical feature in the case before us, was the frequency of the above mentioned callous degeneration of the capillaries. This alteration of the capillary endothelium is, as it seems, always the result of an obstruction of the circulation in the vessel, although not always that of an occlusion by an embolus. The latter may just as well, according to circumstances, be followed by necrobiotic processes, the disintegration of the vessel and the transformation of the nuclei of the endothelium into granule cells; or by an entire dissolution and necrosis, together with the surrounding neuroglia and nervous tissue. Of these two, the one is more frequent in, or in the neighborhood of hæmorrhagic foci, the other in cases of the entire cutting off of areas from the general circulation, by the occlusion of a larger supplying artery. In capillary embolisms, the fatty fur, especially around the nuclei of the endothelium cells, (see plate I, figs. 1, 2 and 3,) is the most frequent occurrence. Besides this, however, the so-called callous degeneration seems to play a role of some importance, of which illustrations are on the same plate, of the appearance of single branches, as well as of anastomosing vessels, figs. 4, 5, 6 and 7. Yet, I may be permitted to add, that they are not presented here as anything new, but as an anatomical fact, which has, as it seems, not fully received its due consideration and interpretation.

The history of the second case was, briefly, as follows: A man, 35 years of age, of good habits, active in business, and in apparent good health, while traveling on business in a western State, went to bed in the hotel, where he was stopping, without complaining, or anything peculiar being observed about him. In the night a noise was heard in his room, and he ran down stairs and into the street in his night-clothes. He was followed and returned in a state of delirium and declared that persons were pursuing him. It was found that he had knocked the panels of the door out with his chair, and thus escaped. After being sent the following day to the business house for which he was acting, he, being most of the time in a comparatively quiet and rational, though at times delirious state, insisted on adjusting his accounts, which he did accurately. He soon, however, passed into a state of delirium, and was brought to the Asylum. During the whole of the journey of twenty-four hours, he alternated between a dazed condition, in which he mumbled to himself, and periods of delirium, but did not seem to recognize those about him; and, during all this journey, he at no time slept, neither were they able to give him any nourishment. In the office he was examined by Dr. Gray. He made no responsive reply to any—even the simplest—questions asked him. He then seemed to be in a dazed condition, muttering to himself and looking about the room. His mouth and tongue were dry, temperature 102 Fahr., pulse 100, the pupils slightly contracted; his hands in more or less constant motion, attempting to take off his coat, picking at his clothes. He continued in this condition about four days, when the delirium became less, and although he was quiet, he had no appreciation of his state, and made no response in answer to any questions. On the evening of the fifth day, he

began to breathe more slowly and to show signs of stupor, but could easily be aroused. At the same time his face and extremities were purpled, the pupils contracted and did not respond to light; the temperature the same. After a few hours this passed off. On the following day, he again passed into the same state of semi-consciousness, with the same general manifestations, and so continued for some hours, with a rise of temperature to 102.45° Fahr. On the seventh day he was lying quiet in bed, but was still incoherent and confused; pupils small, but responding to light; face less blue and congested; respiration 20; pulse weak, 120; temperature 102° ; the lips and tongue dry and cracked. Late in the evening he passed again into a semi-comatose condition; was not able to swallow anything; face and extremities were cyanosed; respiration 24, shallow; pulse 112; temperature 103.5° . From this attack he could not be aroused, and continued comatose until 4.45 p. m. the following day, when he died. The diagnosis was: Diffuse cerebritis associated with capillary embolisms. The autopsy revealed a dilatation and bulging out of the longitudinal sinus; slight ecchymoses at the inner leaf of the dura mater; a high degree of venous and arterial congestion of the pia mater over the whole convexity of the brain. The temporal lobe of the left brain was soft to the touch; that of the right in a lesser degree, and the same condition was found at the parietal and the lower frontal convolutions. Both lateral ventricles contained a fluid bloody exudation. An examination of the other organs of the body was not made.

Microscopic sections showed in the convolutions of all the parts mentioned, most extended capillary embolisms, which were less frequently found in other sections of the organ. There were also numerous cap-

illaries showing fatty infiltration and callous degeneration of the endothelium, and a great number of the cell-like bodies described in the foregoing in the convolutions prominently affected by the capillary occlusion. The tissue bordering the lateral ventricles was infiltrated with red blood-corpuscles, which presented in many places already an altered condition; in others, the recent migrated corpuscles. The infiltration was, therefore, not an evidence of an actual hemorrhage, but of a slow, continuous diapedesis of the blood-elements.

The case, as it will be observed, presents in the main features very much similar to the one related above. Symptomatically there was the same prevailing acute delirium. Etiologically overwork was ascertained as the prominent psychical factor. The physical cause, as we have learned from information later received, was very probably a malarious infection which preceded the attack. The anatomical conditions were in both cases alike even in details.

If we recapitulate, in short, the principal features presented in both cases, we have an acute delirium, so strongly simulating mania that it may at least be said to lie on the border line of true maniacal excitement of the insane; in both, etiologically, a psychical and a physical factor, and, as the anatomical basis, an acute disease associated with a diffuse cerebral affection; in both, a coincidence of circumstances and effects composing the very soil in which acute insanity roots, and from which it draws its nourishment.

ON SOME CHANGES IN THE GANGLION
CELLS OF THE GREY CORTEX OF THE
BRAIN IN ACUTE DELIRIUM, AND
THEIR RELATION TO THOSE
IN ACUTE INSANITY AND
IN DEMENTIA.

BY THEODORE DEECKE.

In the cases related in the preceding article—to which I must refer the reader for particulars in order to prevent repetitions—an excellent opportunity was given to demonstrate the existence of palpable structural changes in the ganglion cells of the convolutions in a diffuse cerebral affection, which presented during the short term of its duration, symptoms of a delirium resembling closely the acute maniacal excitement of the insane. It is well known that a great number of authors up to the present time consider the phenomena of delirium, as well as acute insanity itself, as merely functional, and, while they admit that these conditions are mostly associated with grave disturbances of nutrition, and perhaps material alterations in the vascular system, they deny the occurrence of any visible changes in the structure of the nervous elements themselves. This view has been opposed to the experience of Dr. Gray, of Utica, and since my official connection with the Asylum as special pathologist, I have given this question the most careful investigation, and I have in the annual reports described the conditions observed in such cases under the terms of cloudy swelling, of contraction, and of the glassy opacity of the pyramidal

cells of the convolutions; though I was for some time in doubt concerning some of the anatomical details of these conditions. It was furthermore desirable to study the objects *in situ*, if possible, without changing anything; and to avoid the use of agents which, by chemical action, could be suspected of producing changes in the tissues. There was also some ground to expect alterations in these most delicate structures from the cessation of the chemical and physiological processes of life in the tissues. In order, therefore, to take all this in due consideration, I have delayed the publication of observations made some time ago until by a broader experience I should be able to demonstrate the correctness of the results obtained.

The best results are obtained from the immediate examination of the fresh brain tissue. With a sharp knife, kept wet with water, to which a small quantity of glycerine has been added, or even directly in this liquid, microscopic sections can be made sufficiently thin and transparent as to permit the use of all the higher magnifying powers applicable in histological investigations. The liquid in which the sections are mounted is diluted glycerine; and no pressure is allowed to act upon the specimens other than that which the thin cover-glass exerts when of the embedding fluid so much is removed by blotting-paper, that it just fills out the empty space between the slide and the cover. Thus the margin only of the section comes into contact with the fluid, while its surfaces are spread out smoothly on the glass surfaces. In such preparations the vascular arrangement, the distribution of the nuclei of the neuroglia, and the ganglion cells and nerve fibers in their natural appearance and position, are brought to view with great distinctness. The long processes of the pyramidal cells, which extend toward the periphery of

the convolutions, may be followed up to three and four times the diameter of the field of vision of a one-fifth objective. The condition and position of the nuclei and nucleoli of the cells can be clearly pointed out, as also the roots at the base of the cells and their origin. All this, however, will not visibly be altered when the fresh sections are soaked for staining in a carmine solution, to which a little glycerine has been added. They imbibe a small amount only of the coloring material, yet some details of structure may become thus more distinctly outlined. I have, therefore, most frequently in successive sections employed alternately both methods.

Now, if in such preparations in the same field of vision, a certain number of ganglion cells exhibit marked changes in structure and others not, or when in successive sections of certain convolutions changes are observed which are absent in other convolutions, it is evident that these facts admit of but one interpretation. The changes can not have been produced artificially by the action of foreign substances, because there has none been brought into contact with the specimen. There has also no instrument been used to tease the tissue, and no pressure by which the natural condition and form of its elements could become altered. Yet, even if the former had been done, it can not be seen why it should have affected in the same specimen some of its constituent elements, and others not. For the same reason, also, we can not assume that the changes observed were produced in the act of, or after, the death of the tissues. It remains, therefore, only to conclude that they are the result of natural causes, which existed previous to the extinction of life in the tissues; that is, previous to the cessation of the chemical and physiological processes of life.

We do not have, it is true, any knowledge as to what movements and alterations these most delicate structures perhaps are subjected in connection with the normal manifestations of life, yet there are no indications whatever that they are of other than of a molecular nature, by which, according to ingenerate organic laws, in spite of all interchanges of matter, the individual elementary form is preserved. On the contrary, however, associated with established deviations from the normal interchange, we presuppose that for this change of circumstances, a physical formative equivalent must be demonstrable, and, vice versa, that changes of form and structure can but be a manifestation of the existence and the influence of modified processes of life.

With this we enter into the natural relations between cause and effect, as an association of facts. But in this I am far from suggesting any attempt or effort to explain the nature of the one by the nature of the other. This would be, in my opinion, entirely beyond the limits of scientific investigation. And it appears ridiculous when a third associated element is called forth, the clinical symptoms by which the affection manifests its existence during life, to face the anatomical and physiological facts observed and deduced.

I make this remark because I am aware of the lack of sound philosophical principles, and of the great confusion of ideas in some very pretentious representatives of science, who not only themselves find pleasure in the attempt to explain the clinical manifestations of a disease* from the nature of the anatomical conditions found after death, but who also demand of others to undertake the same task.†

* This JOURNAL, Vol. XXXIV, page 80; Article, Katatonia.

† *Chicago Journal of Nervous and Mental Diseases*, April, 1880, p. 297: "In cases of *psychical* derangement, not only to *accurately localize* the disease, but also to *explain* from the *seat* of and the nature of the *lesions* the *symptoms* which marked the case *intra vitam*."





FIG. 3.



FIG. 4.



FIG. 5.



FIG. 6.



FIG. 7.



FIG. 10.



FIG. 14.



FIG. 8.



FIG. 9.



FIG. 11.



FIG. 13.



FIG. 12.

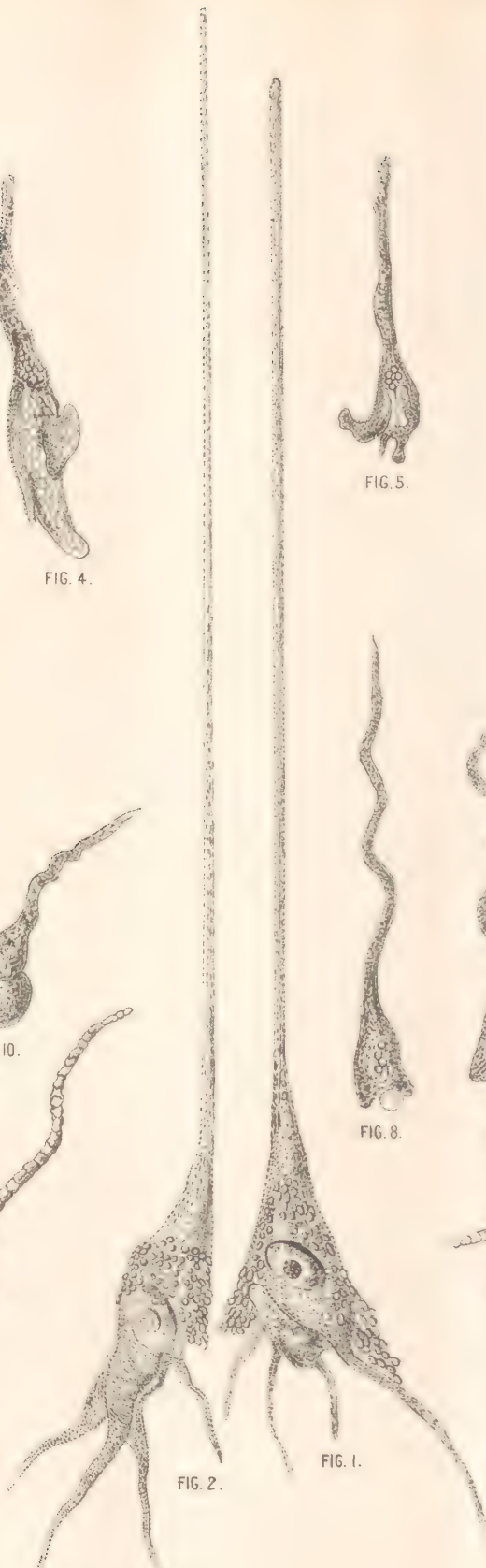


FIG. 1.

FIG. 2.

I wish, therefore, to be rightly understood that I do not believe in any such absurd views; to illustrate, who would suggest that the phenomenon of cough is explained by the detection of a morbid condition of the lungs, or of the other air-passages; or, that in a given case the general rise of temperature observed is in any way explained by, let us say, the detection of a discharging abscess somewhere in the body; or, that special phenomena of insanity are explained by the detection of certain changes in the vascular arrangements or in the ganglionic cells of the brain, &c. All such attempts are the results of untrained thought, and of an entire misapprehension of the relations of facts and of the relations between cause and effect in nature. I have sought to collect facts, and to state the phenomena of the associations of the facts observed, and in this sense I would like to ask the reader to look upon the title and the contents of this article.

The first change in the ganglion cells of the grey cortex of the brain from the natural, is noticed in the appearance of a granular or fatty fur, which, like a loose covering, hangs over the body of the cell. It is much like the one referred to in the foregoing article, which lines the smaller vessels. In Plate II, figs. 1 and 2, I give an illustration of two large pyramidal cells in this condition, which are taken from the third layer of the left anterior central convolution. (Case II.) The same lesion, as is well known, has been observed by others, and was described by Voisin,* who gives, however, a very inadequate illustration of it. Occasionally a similar condition may be found in one or more of the convolutions of the brains of persons who have died

* *Leçon Clinique sur les Maladies Mentales.* Paris: 1876.

without having shown any symptoms of cerebral affection; yet, in cases like those here related, and in acute insanity, they are of so frequent occurrence, exhibiting all degrees of the affection, that there can be no doubt as to their pathological character. It can furthermore be shown, that they are more frequent in those parts of the grey cortex in which at the same time marked vascular lesions are demonstrable, like those referred to in the foregoing article, and others which will be described hereafter. As to their origin and meaning, there can, as I believe, be no doubt. The deposits are of a fatty nature, and must, as such, be attributed to a defective local combustion or oxidation, brought about by an insufficient supply of the tissues involved, with arterial or oxygenated blood.

The cells themselves, during this affection, retain, as it seems otherwise, their natural form and appearance; the peripheral protoplasmatic processes and the roots at the base of the cell are not altered, as far as the microscope reveals, and the nucleus and the nucleolus of the cells are distinctly outlined and show no change of position. There is, therefore, no reason to assume that the affection indicates a lesion of a permanent or progressive character, provided that relief is accomplished from the main cause of the condition, the defective nutrition or defective aeration of the tissues involved.

Now, in the progressive stages of this affection, we notice that the parts of the cells which become next involved, are the roots at the base, and probably at the same time, the nucleus. Of an intermediate state between these two, I have not, as yet, had a perfectly clear illustration; and I retain, for this reason, the sketches made, as at present, not decisive. More evidences are, however, on the side of changes in the condition of the roots, as preceding the others. The roots

appear shriveled, contracted or drawn in, somewhat like the feelers of a snail; and in farther advanced stages, they almost entirely disappear.

It may not be improper to remark here, that from my study of the nature of the cells and their processes, I can not relate a single instance in which one of the basal roots was seen to terminate in a nerve fibre, forming its axis-cylinder, as is generally accepted as a fact. This theory, as it is known, is entirely founded upon the supposed analogy of these cells to the great ganglion cells in the spinal cord, and not upon direct observation. Yet, there is neither a physiological necessity for this, nor does it in any way facilitate a better understanding; the prolongations may just as well, in fact, be the central sensitive expansions of the ganglion cells, and the term feeler or antennæ of the cells, may not inadequately be applied to them. Now, this interpretation may be right or wrong; the fact, however, can not be denied that the first, or one of the first structural changes of the pyramidal ganglion cells of the brain takes place in the protoplasmatic processes at the base of the cells, and that the changes appear in the form of a coagulation or contraction of the processes. And this fact seems to be the more interesting, as, undoubtedly, the first manifestations of psychical disturbances point towards some interruption or disorder in the central centripital tracts, or in the sensitive sphere of the central organ. I do not, however, propose to enter, here, into theoretical considerations, which will be made the subject of another article.

I have observed the structural changes at the base of the cells in the two cases described in the foregoing article. These changes are of constant occurrence also in acute insanity, and represent a morbid condition of the nerve cells, which, as we must suppose, under favor-

able circumstances, are capable of restoration. Yet, in farther advanced stages, where the body of the cells and the nucleus begin to participate in the changes, the possibility of this may perhaps be questioned. Figs. 3 to 6 are illustrations of these latter stages. The roots at the base of these cells have entirely disappeared; the protoplasmatic body of the cells is contracted and more solidified, as it seems, than in the normal state. In fig. 3, a fissure in the protoplasm is seen, through which the nucleus projects. In fig. 4, an entire division of the protoplasm has taken place, the lower part shows a finely reticulated structure, the upper is irregularly contracted and dilated, while the nucleus, opaque and altered in form, seems to be at the point of leaving the cell. In both cells, however, the peripheral processes, which are omitted in the drawing, preserved their normal appearance, as shown in figs. 1 and 2, in a perpendicular line, tending toward the periphery. In figs. 5 and 6, varied appearances of the contraction of the cell protoplasm and the nucleus are given. Figs. 7, 8 and 9 are drawings of some further changes, which illustrate more advanced stages. In these, the peripheral processes also exhibit signs of being affected. By an irregular contraction, they become more or less tortuous, are granular, and can not be traced far upward from the cell; here and there they are of a varicose appearance, as in fig. 10; while the cell body itself has passed over into the condition of cloudy swelling.

The most advanced stage of the degeneration of the ganglion cells in acute insanity, at least as far as I have observed, is illustrated in fig. 11, which represents the "glassy opacity" of the cells. Even in this state we may sometimes succeed in discovering a nucleus inside the cell, which, perhaps, indicates that life was not entirely extinct.

From a physiological point of view, we would conclude that at least the stages of change illustrated in figs. 3 to 11, are of such a character that they must be associated, in their progress, with an entire inhibition of function. This complete arrest of function is, of course, not present in the beginning of acute insanity. Yet, it must be remarked that, since all the cases which come directly under histological observation terminated fatally, we have no right to claim that alterations of that kind *necessarily* occur in cases which take a favorable course. They are, therefore, not more than types of histological changes observed in cases of acute insanity, which terminated fatally. However, I should be inclined to take a little different view of the earlier stages of change from the normal, of which we, likewise, found examples preserved in the tissues examined. They would, physiologically, of course, not amount to an inhibition, but to a limitation of function. Now, for this, at least, one anatomical equivalent is offered in the early affection of the basal processes of the pyramidal cells, and it will be admitted that the earliest characteristic symptom of insanity consists in an embarrassment and limitation of function.

With this, however, we do not exclude the possibility of the actual occurrence of the farther advanced changes in cases which take a favorable course. An inhibition of function, in a physiological sense, does not involve the anatomical destruction of the organ, or its constituent cell elements, and does not exclude the possibility of a return to the normal condition, as long as the destruction is not anatomically complete.

With a very different view, therefore, we would look upon the transformations of ganglion cells, as presented in figs. 12, 13 and 14. In these, there is no anatomical element left of the original cell, aside from a resemblance

of the external form, and no element to which any interchange of matter in a physiological sense, could be attributed. We have called this condition, for some years past, the *pearly degeneration of the pyramidal cells of the convolutions of the brain*. It is the entire mortification of the cell, and I give the illustrations of this condition, for the purpose only of comparing them with those described in the foregoing. They are a constant feature in cases of dementia, and most frequently found in the precentral and the upper frontal convolutions. Yet, I do not intend to enter, here, into any topographical details, and must leave the working up of the material collected in reference to it, to some future occasion.

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